INDUSTRIAL CONTROL

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THE APPLICATION TO INDUSTRY OF DIRECTION, CONTROL AND LIGHT

BY

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FOREWORD

THE purpose of the author in publishing these lectures is to set before those who are engaged on organization work the true fundamental laws governing all direction and control, and to show how these can be, and have been, applied to Industry with complete success in every case.

Notwithstanding the works which have already been published concerning scientific management, the author places before the industrial world in particular an entirely original statement of laws and axioms, which have for their special claim certainty, simplicity, order, and reason, and which, moreover, he believes have been as yet untouched by the exponents of scientific management.

That these laws and axioms have always been in existence will be obvious to those who study these pages; it is further obvious that they must govern all scientific management, and it can only be after the laws governing direction and control have been understood that true scientific management can ever be rightly

interpreted and applied, collectively or individually, to the nation, the factory, the man, or the machine.

These lectures were originally delivered at the Mappin Hall, Sheffield University, and it was owing to the keen interest displayed that publication was undertaken. Further research into this subject, since the lectures were given, has revealed that light is inseparable from direction and control, and that attempts to separate it must lead to confusion, and from confusion to chaos. This axiom has led to considerable revision of the lectures. It is *an axiom of the utmost importance,* for it supplies the line along which not only factories but nations must travel, so as to arrive at " order," it provides the starting-point not only for solving industrial problems but for solving all problems, whether theoretical or practical, and it throws light on to the confusion which is leading the world towards chaos, and by so doing enables the world to find " order " by walking straight towards the light, instead of wandering through the gloomy paths of confusion.

All of those in whose factories a system has been installed embodying these laws and axioms have nothing but praise for the result obtained. Many of those who attended the lectures have,

of their own accord, written to say that they received tremendous benefit, and it is the earnest hope of the author that many more will receive inspiration by studying these lectures. Students are warned of the importance of the first lecture, and are advised to read this a second time after finishing the book.

In conclusion, the author wishes to record his appreciation and thanks to those firms mentioned in these pages who have in each case willingly permitted publication of how their own problems have been solved, and by so doing have shown that they are prepared to apply the law of mutual accommodation to their own competitors.

In developing these lectures the author has not been single-handed—many friends, unknown and known, have helped in many ways, and it is not from lack of appreciation of these that only one name is mentioned—that of a loyal assistant and friend, Mr. C. H. Draycott, who during the last few months has added largely to the progress made in the theory and practice of Direction and Control by exposed records.

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INDUSTRIAL CONTROL

LECTURE I

INTRODUCING CERTAIN DEFINITIONS, AXIOMS, AND LAWS GOVERNING ALL DIRECTION AND CONTROL

"And God said, Let there be light."—*Gen.* i. 3.

IN order to understand what is meant by the words "direction" and "control" it is necessary to develop the meaning from accepted definitions.

The first book of Euclid commences with definitions, which may be termed accepted; the first three of these are:

(1) A point is that which has no part.
(2) A line is length without breadth.
(3) The extremities of lines are points.

Euclid does not state the value or utility of a point, but this can be inferred from every one of his problems. The first proposition instead of being worded: "To describe an equilateral triangle upon a given finite straight line," may

be worded: "To find the position of a point from which, when straight lines are drawn to the extremities of a given finite straight line, those straight lines shall be equal to the given finite straight line."

This wording reveals the value of a point, for, until the position of the point is found or known, the point is valueless. Further, in every problem in Euclid and elsewhere, the position of a point or points has to be found before the problem can be solved.

If the position of two points A and B is known, then the position of the straight line joining those two points is known, and consequently the way or path of anything moving along that line is known to be either from A to B or from B to A.

Direction can therefore be defined as "a line, whose position is known." Thus, in order to know the direction of anything, it is necessary to know the position of the line. Hence:

To direct, the position of the line must be known (Axiom A).

This knowledge should consist of the clearest perception or "vision"; it should combine history with philosophy and mathematics, etc., it should combine the "that it is" with the "why it is" and the "how much it is," etc.

Now, the extremities of a line are points, but direction is primarily dependent on the position of one point being known.

Consider three types of line, firstly the straight line AB. The position of the straight line cannot be known unless the position of the extremities is known. But the point A primarily governs the position of the line AB.

Secondly, consider the simplest curved line: that of the circumference of a circle. This line is generated by the point B, at one extremity of a given finite straight line AB, being moved, and the point A at the other extremity being fixed. The position of both points must be known in order to generate the curved line of the circumference. In the same way, the position of the surface of a sphere is located by the moving point B, but is primarily dependent on the fixed point A.

Thirdly, consider any curve. Let AB and BC be two given finite straight lines of equal length, the point A being fixed and the points B and C being movable. The point B can only move on the surface of a sphere, and the point C can consequently generate any curve which lies within a sphere whose diameter is not greater, than four times the length of the line AB. Thus anything can be moved in any direction,

if the position of the point A is fixed and there are two given finite straight lines with a common point B. Consider a practical example by moving a book off the table on to a chair. By sitting still point A (in the shoulder joint) is fixed, point B (in the elbow joint) is movable; point C, the centre of the book held by the hand, moves in any curve.

Thus the line, surface, and shape is primarily controlled or governed by a point, whose position is known.

Control can therefore be defined as "a point, whose position is known, which decides direction," which as an axiom may be stated:

Control cannot be efficient without vision and decision (Axiom B).

Now a true definition must be applicable to all science, thus, when considering time problems, the point must be known. Consider a straight line time problem. The point in time is the present, or "now," as distinct from the line of time in the past or the future. "Now" has no part, it is the true point from which time in the past or the future is measured: it is the dividing-point between the past and the future. Without knowledge of the position of this point, confusion would exist. The egg would not be boiled correctly for breakfast unless

the "now" when it started to be boiled was known (from which the time for boiling could be measured), and the "now" when that measurement of time was completed was known. The line of time from the first point "now" to the second point "now" measuring three and a half minutes. If these "nows" are not known, confusion commences in domestic life by indigestion from a hard-boiled egg or bad temper from a sloppy egg.

But if the position of the point is not known, the position of the line is not known, and hence the measurement or scale is not universally accepted. This leads to greater confusion.

Consider a straight line numeral problem. In numeral problems, "zero" or "nought" is the known and accepted point, the true point, which has no part, from which all counting starts. What happens if every one starts from a different point and uses a different scale? Fahrenheit, suffering from indigestion, would meet Réaumur suffering from bad temper, and the following conversation would take place.

FAHRENHEIT. "Good-morning, Réaumur. Cold this morning. Eighteen degrees of frost."

RÉAUMUR. "Yes, it's cold, but your thermometer is wrong. There are only eight degrees of frost."

The argument starts and leads to greater confusion. Yet both were right from their own points on their own scales, for eighteen degrees of frost on the Fahrenheit scale equals eight degrees of frost on the Réaumur scale.

Thus it can be seen how confusion grows through not knowing and accepting the position of the control.

Confusion at its maximum is indescribable confusion or "chaos," but this maximum can only be reached in total darkness, for light enables some description of form to be retained in the mind. Without light, the mind cannot retain the form of the chaos, for form is then without form to the mind.

Having now arrived at that state of affairs where no position is known, it is necessary to consider how order can be brought out of chaos.

Total darkness exists; the position of no point is known; therefore no control or direction exist.

Light is the first principle and the only first principle, so far as man knows.

As soon as light is supplied the position of the first point is known, for the centre of that light is that point.

Thus in the history of the Creation a command is first given for light in order to bring order out

of chaos; and then division is made between light and darkness.

How was this division caused?

Light penetrates darkness, it makes darkness light, it sends out innumerable points of light in every direction, which all travel at the same speed in a straight line. Thus every point of light from a given light generates a straight line or ray, one extremity of which is the given light and the other extremity of which, unless stopped by matter, may be found on the surface of an ever-increasing perfect sphere, whose centre is the centre of the given light.

This property of light is known and accepted: hence a method in which light and darkness were divided must be accepted, for the surface of an ever-increasing perfect sphere is always a definite division—*i.e.*, light inside the sphere and darkness outside.

Thus instantaneously with the creation of light, four things happen.

(1) *Control*—a point, whose position is known, which decides direction. A point which mathematically may be represented by o.

(2) *Direction*—a line whose position is known, which mathematically may be represented by R.

(3) *Division or Surface*—represented mathematically by R^2.

(4) *Form or Shape*—represented mathematically by R^3.

(N.B.—The formula for the surface of the sphere is $4\pi R^2$, and for the cubic contents of the sphere $\frac{4\pi R^3}{3}$, but these constants have been left out of the above for the sake of clarifying the argument).

Now R^2 and R^3 are only direction (R) raised, to the power of 2 and 3 respectively. Hence it is a self-evident fact that: Direction, control and light are inseparable (Axiom C).

Attention must now be given to what is meant by industry.

Anyone, who possesses a conscientious habit of applying himself to any manual or mental work, may be called industrious. Industry is a collective word—thus the motor-car industry comprises all those individuals who devote their time to the manual or mental work connected with making motor-cars. But all those who devote their time to this work are not industrious, many are lazy; and the result of collecting together industrious and lazy people and referring to the group as an industry is to cheapen the value of the word "industry," without affecting the value of the word industrious when applied to the individual.

Thus industry may be considered under the headings of manual and/or mental work.

Manual work is manufacture, or "doing."

Manual and mental work is "thinking about what you are doing."

Mental work is thinking.

In dealing with any subject of the magnitude that manufacturing embraces, it is first of all essential to define what is meant by manufacture, and, since laws and axioms are to be applied, it is necessary to give as wide and as broad an interpretation of the *meaning of manufacture* as is possible.

The derivation of the word supplies a definition of "something made" or "done by hand." The word "made" must be qualified: it must not be used in the sense of creation; for man has never had the power to create, he has only had the power to alter or transform material which was created long before man's existence. The word "hand" must also be used in the sense of an instrument used for doing something.

An analysis of the power of manufacture that is given to man reveals the fact that this altering or transforming of material can be divided into three distinct groups. The first group may be called the "dissembling group";

the second group, the "forming or deforming group"; and the third group, the "assembling group."

To take an example: Man digs in the ground and obtains an ore—he *dissembles* the ore from the earth. By certain processes of manufacture he *dissembles* the cast iron from the ore, leaving other materials or matter, which may be called by-products. Having dissembled the cast iron from the ore, he may take it a step farther and convert it into steel by process of manufacture. The conversion is done by *dissembling* certain impurities from the cast iron, and *assembling* with the cast iron certain elements of a strengthening nature. The material, which is now called steel, may be "formed or deformed" by rolling, and further by drawing. It may be *dissembled* into short pieces; or *formed* or *deformed* into various shapes by forging; and so on. No matter what operation is carried out on that piece of steel, it must belong to one or more of these three groups. When it has arrived at the final form, it may be *assembled* with one or more articles (which have gone through the same or different types of process) into one complete article.

No matter what sphere of manufacture is considered, whether it is making a pocket-

knife, a loaf of bread, or a coat, each operation embraces either dissembling, forming, or assembling.

Thus from the analysis information is obtained which enables a diagram to be made showing the evolution from the time when man starts to manufacture to when he finishes the complete article—an article which, when completed, is sooner or later again dealt with by nature.

The accompanying diagram, Fig. 1, shows the chief operations through which a piece of iron ore will travel in order to reach the final state (such as a rivet of a bicycle chain). A brief study of this diagram reveals the fact that where two lines fork from one factory there is dissembling taking place, and where there are two lines leading to one factory there is assembling taking place. Thus assembling is shown as equal, yet opposite, in sign to dissembling. The usual sign employed for forming is that of a straight line joining two stations.

From this brief survey of the principles of manufacture we can obtain the following axiom: Since matter is indestructible, it follows that manufacture can only consist of dissembling, forming or deforming, and assembling (Axiom D).

In the same way, "mental work," or "think-ing," may be divided into the same three groups: thus, by adding one thought to another a solution to a problem may be arrived at, and this adding of one thought to another is assembling thought

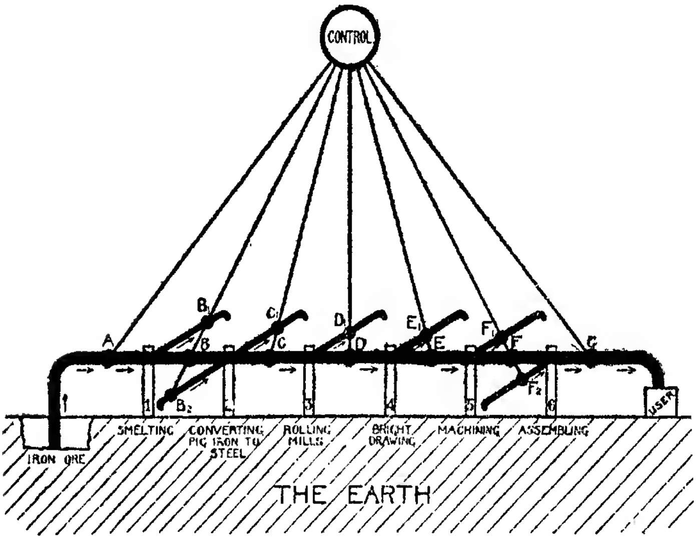

FIG. I.—SHOWING STAGES OF MANUFACTURE.

(synthesis). Or a solution to a problem may be found without knowing the proof, and by process of "dissembling" the solution (analysis) a proof may be arrived at which establishes the solution.

There is no doubt that such master mathematicians as Thales, Pythagoras and Euclid made certain discoveries concerning the properties of triangles, and by process of "thought dissembling" established proofs, which are presented to the public in "assembled" way.

The "forming" group of thought is so common that most thinkers use it unconsciously. All the great teachers use this group for teaching. Thus Christ, when He is teaching, starts off, in numerous cases, with a thought about the earth, and then "forms" this thought into a thought of heaven. Parables, proverbs, analogies, metaphors, etc., belong to the "forming" group of thought.

In just the same way that material, such as a piece of wire, can be bent or "formed" into different shapes, each of which is useful for different sorts of "manual work," so can a thought be "formed" into different words, each of which is useful for different sorts of "mental work."

The last paragraph is an example of a thought "formed" from a thought about "doing," to a thought about "thinking." This makes two thoughts, which can be "assembled" into one thought—namely, that "words bear the same relation to thinking as shape does to material."

There is no doubt that the solution of all industrial problems may be found in nature's factories, providing we have a sufficient vision to see the parallel. Hence the importance of vision. This can be accepted as certain if one is prepared to accept the axiom that the addition or multiplication of coincidences constitutes proof. Every man really accepts this axiom; but the more conservative a man is, the greater number of coincidences he requires.

Now in trying to discover the perfect factory in nature, it is necessary to consider the animal and vegetable worlds separately. In the animal world we must consider the factory of the animal which is most progressive, and here we naturally presume that man is far ahead of all the animals. Consider for a moment the factory which maintains life in man. Inside the marrow of man's bones there is the most perfect manufacture going on continually. Cells of various shapes, sizes, and descriptions are continually being created, and are being distributed to the various parts of the body for maintaining the system. It is an accepted fact that right throughout the body there is a perfect system of telephone wires, and that the brain directs and controls through these wires. It is further known that the brain is

divided into two main portions—the *cerebrum* and *cerebellum*—the cerebrum being considerably larger than the cerebellum. The function of the cerebrum appears to be that of collecting together many ideas, which it joins together and comes to some conclusion about—in other words, THINKING. The cerebellum, in point of position, is underneath the cerebrum, and all the telephone wires converge in close proximity to the cerebellum. This fact, and many others which need not be entered into, tends to prove that the *cerebellum controls instantaneous action.*

Thus there are two distinct, but co-ordinated, functions of the brain—namely, *thinking* and *doing, or action.* Neither can exist without the other, and all organizations for the maintenance of life come under this supreme control of the brain. A breakdown in this control affects the whole organization and sooner or later terminates life.

Consider next an example of direction and control in the body: the heart, which is the pumping-station or that which supplies motion to the blood, drives the blood through various arteries. The arteries run in various directions, and the circuit is completed by the blood returning to the pumping-station through veins, and, in order that the blood may always travel the

same way in these veins, non-return valves, which decide direction, are arranged along the line.

In order that we may be conversant with the difference between direction and control as applied to manufacture, it is as well to consider further parallels.

Everyone will recollect that in the days when motor-car reliability trials were being carried out it was necessary, first of all, to decide upon a course. Thus the direction having been once settled, the motor-cars could not all be started together from the starting-point, since the width of the road primarily prevented it. Further, in order to safeguard against accidents, it was deemed advisable to start only one car at a time, and limit the number in each section of the road. Thus the course was divided into sections, there being a control station at the beginning and the end of each, at which the cars were stopped and the time taken. These controls were used for checking the time taken in each section, and also to prevent confusion occurring in any section by regulating the number of cars in that section.

Thus we have the valves to control the flow of blood in the veins, the control in a motor race, or the signals acting as a control in each

section of the railway line; and numerous similar examples could be given.

In each and every case control is established to prevent confusion.

No matter where you look in the things that are done by man you can see, if you study the subject, that direction and control exist separately, but that one cannot exist without the other. If you ask a man in the street to direct you to a certain place, he will give you the direction, but you cannot arrive at that place unless the method by which you are travelling is under control. In walking, your cerebellum controls your legs so as to walk in that direction—a direction which the cerebrum holds. If you are motoring, your cerebellum controls your hand, which in turn controls the steering-wheel. The same difference between direction and control may be located in everything that man does.

It is so important to be able to differentiate between these two functions that those who are studying industrial administration should first learn to differentiate between direction and control. Wherever you go, or whatever you do, you can, if you keep your eyes open, see the difference. You can see it when you are having your hair cut—the barber's comb sup-

plying direction for the scissors, to cut along, or, in places where he does not use a comb, one blade of the scissors is held fixed, and the action is supplied by the other blade. Most of what is commonly known as "knack" is really knowing how to differentiate between direction and control. There is little doubt that a large number of skilled trades can be learnt in a few weeks if the apprentice would only start by differentiating between direction and control. The same applies to sports—thus, in billiards, a novice may improve his game 20 per cent. if he differentiates between direction and control. Direction in this case is supplied by putting the body in such a position that the centre line of the forearm and the cue pass through that point on the striker's ball which he requires to hit with the cue, and the point of the object ball which he requires to hit. While doing this he must brace his body up, so that, when the order is sent down for the arm to strike, the equilibrium of the body is not disturbed. Having done this, he must look at the point on his ball that the cue must hit, then the order may be sent down to the arm for action. Hence billiards requires a good deal of brain work, and if the brain is tired the player cannot expect to play his best.

Before passing on to direction and control in the vegetable world, it is as well to consider what other animals know about manufacture.

Those who have studied the ANT and the BEE cannot agree as to which is the cleverer of the two—both of these creatures have trades, but have not separate trade unions for each trade. They have one union for all trades, and in this particular, and also in working without any medium of exchange, they are far in advance of man.

There is one sort of ant in the tropics which divides its work up into operations—thus, when it is building a house, one lot of ants climb up the fruit-trees and cut portions of the leaf away. These drop to the ground for another set of ants to pick up and carry away to the builders, who are also supplied with a sort of mortar by a further set of ants. Thus the first set of ants are dissembling, the second set are transporting (and, for reasons which will be obvious later, transporting may be considered in the forming group of manufacture), the third set are assembling the mortar and the leaves, and so on. While this is going on there are non-productive workers—another trade—who are on the look-out for enemies, so that work can be carried on in such a way that the maximum efficiency

is obtained. This group is known as soldiers, and is trained for fighting. At the head of this beautiful organization there is a queen; But whether that queen sends orders by thought transference, or what method exists for transmitting orders, is a matter upon which natural scientists are not yet in agreement. But scientists are agreed that such an organization could not be carried on unless there was unity of control from the queen and unity of purpose among the workers. This unity of purpose may be considered as the ant's way of expressing the law of mutual accommodation. This phrase—the law of mutual accommodation—is borrowed from a book written many years ago by Mrs. Gatty, called "Parables from Nature." In one of these stories Mrs. Gatty tells the children how certain trees accept the law of mutual accommodation, and other trees do not.

Now, throughout the animal, vegetable and mineral worlds the law of mutual accommodation is found to exist. To start with the elements, it is known that all atoms of one element are of the same size and weight, and take up the same amount of space, providing temperature is constant. This law is absolute, and, as far as the elements are concerned, may be applied everywhere.

In the vegetable world, as already stated, the law of mutual accommodation is partially accepted. Each plant possesses to some extent the power of accommodation, but such accommodation is not always mutual, as far as its neighbour is concerned. As an example: the convolvulus will accommodate itself and grow over anything, irrespective of whether by growing over its neighbour it smothers it. Against this there are trees which will not grow into each other, but will expand away from their neighbours.

In the animal world, the law of mutual accommodation should never be lost sight of: the ant accepts it, man loses sight of it. Thus we find a man, who considered himself capable of controlling the world, refusing to accept this law. If that great genius (?) the ex-Kaiser, had, in his youth, accepted this law, there is little doubt that by now he might have been director and controller of the world, instead of sawing wood. Right through his life there exists that colossal blunder of refusing to accept the law of mutual accommodation. The declaration of war by this country in August, 1914, was owing to Germany overrunning Belgium like the convolvulus overrunning the laurel-tree. Great Britain owes

her position in the world to accepting this law. The success of the food control which had to be established in this country, was primarily due to the nation as a whole demanding that the law of mutual accommodation be applied: all will remember the cries: "Stop the food queues!" "Share and share alike!" Germany had an elaborate system, but the nation had not been taught to accept this law—the law was not part and parcel of that nation, as it is with this. Hence the system met with scant success.

Or, again, why is the police force in this country more efficient than in Germany? Why did the ex-Kaiser always complain of the inefficiency of the police in Berlin, and marvel at the efficiency of the London police?

The answer is, that no police can control traffic unless they and the traffic accept the law of mutual accommodation equally with the law of unity of control.

How is a nation taught to accept this law? Chiefly by example. Take the case of football—everyone knows how one selfish player may spoil a team, how matches are lost in this way. True sport, not of the gambling nature, but true sport for sport's sake, is this nation's greatest asset for prosperity.

Thus, whether one looks at a nation, a factory in that nation, or an individual in that factory, prosperity is found where the law is accepted, and decline where it is not accepted. In modern history there is the decline of Turkey, and each and all of us know of factories and men who have declined from the same reason.

There is only one other law which is of at least equal importance with the law of mutual accommodation, and that is the law of unity of control. No matter which example is taken of those already quoted, whether it is the beehive, the ants' nest, the body, or the vegetable world, there is one control, and one only: the brain controlling all the actions of the body, the signal controlling one section of the line, the queen-bee controlling the beehive; and investigation into history proves that the greatest achievements have been effected by unity of control.

One of the greatest examples of unity of control is that which occurred over 4,000 years ago, when Joseph was made food controller by Pharaoh. There is no better example in history of the value of vision for direction and control than is contained in that apparently simple and straightforward story.

Firstly, Joseph was a man who possessed

vision and decision. A controller cannot be efficient without vision and decision. In his youth, Joseph suffered much on account of this vision; it made him extremely unpopular, and resulted in his being sold as a slave. When, later in life, Pharaoh made him food controller and director because he possessed vision, it is more than probable that he started by being immensely unpopular with those leading men who felt they possessed better qualifications. Pharaoh, however, was no fool; he saw that Joseph possessed more vision than anyone else, and consequently made him director and controller. Probably Joseph's line of vision was somewhat as follows: There will be seven years in which the supply will be in excess of the demand; the result of this will be—firstly, there will be a falling market; secondly, the people will say at the end of the first or second year that they are only going to work half as hard, because they can grow sufficient to keep themselves alive when working short time; thirdly, this will result in decreased production. He knew that it would be useless to tell them that there were going to be seven lean years at the end of the seven fat years, because the majority, being without vision, would not believe such a thing possible. Joseph, then, had to solve

the problem as to how to keep the nation fully employed, and how to keep production at a maximum during the seven years. He decided to make the demand equal the supply. To do this he bought up all the extra supply during the first seven years and stored it. The result of this was that when the seven years of famine came, he sold the corn back—in all probability at the price he paid, for he had sufficient vision to see that the people had become spendthrift during the seven fat years, and that all their possessions must come to the Crown before the end of the seven lean years. That is exactly what happened; the people had to exchange their savings first, then their cattle, and then their lands, simply because the nation had become spendthrift through prosperity. Thus the man of vision not only brought the nation through the fourteen years, but obtained ownership and control of the whole land; for we read that the workers, after being moved from their own land, had to pay 20 per cent. of produce to the State every year as a ground rent.

Now if this example is compared with modern times it appears probable that if Joseph had been director and controller of manufacture in this country when war broke out in 1914 he would have taken adequate steps to prevent

a rising market by selling imported materials, to manufacturers at pre-war prices. The result would have been that instead of this country being in a bankrupt condition to-day it would be in absolute control of all the trade of the world.

Thus it is manifestly unfair to saddle the present Government with the result of lack of vision in the past—for there is not one business man in fifty who would have supported a Government which had taken the step that Joseph would have taken in 1914.

Attention must now be given to the effect of dual or plural control. The late Dr. Bullinger wrote as follows: "We hear sometimes of a dual control, but it is a fiction. It exists only in words, not in reality." Just twenty words with a world of knowledge in them. But, unfortunately, dual control is attempted everywhere. In history we need not go back very far; it was one of the lessons of the war that dual or plural control only results in inefficiency. Everyone knows how dual control existed on the Western front until the middle of 1918, and what results were obtained when unity of control was substituted for dual control. Many consider that war would have lasted another year if dual control had been

persisted in on the Western front. It was not for lack of knowing that dual control was a mistake: it was a point which was being continually brought out by writers in the press; and yet the nation was informed that great difficulties stood in the way of effecting unity of control.

Perhaps the most definite example of the inefficiency of dual control is that of the power of the sun and the moon on the sea. When the sun and moon pull together—that is, when they are in line with the earth (either at times of new moon or full moon)—the tides are considerably higher than when the position of the moon is the first or last quarter. In these quarters the sun and moon are exerting their influence at right angles, with the result that there is a net loss of efficiency in the rise and fall of the tide of about 30 per cent.

The extremity of each end of a line is a point: dual control is attempting to decide direction by placing two points in different positions at each extremity of the line, which is absurd and must lead to confusion. Man has accepted this in every machine that he has designed during the last hundred years. If a motor-car manufacturer to-day designed and put on the market a car with two steering wheels to be

operated by two people at the same time, his friends would seriously consider whether he should be put in an asylum. But hasn't the nation which allowed dual control on the Western front an equal claim for being put in an asylum? Hasn't the director of a business who allows dual control in any shape or form, or the council which issues reports concerning labour problems in a language, which is incomprehensible to the working man, the same claim? And doesn't it all point to the fact that this nation, which prides itself on its common sense, is lacking in knowledge concerning the law of unity of control?

This subject must not be left without some reference to the war which is at present being waged between Capital and Labour. The phrase "Capital and Labour" will not stand analyzing; for before analysis has gone far one comes up against the fact that Labour is Capital, or Capital is Labour. The real war that is going on is between the profiteer and those who are not profiteers. The profiteer is the man who will not accept the law of mutual accommodation. He is doing what Germany did in 1914, "over-running the laurel." Does he realize what must be the result of his greed? Does he realize that the widow, who was left with an

annuity seven years ago which was reckoned at that time ample for her needs, has lost (due to depreciation in value) nearly everything, owing to his "convolvulus" dealings?

In the past, when great decisions have been made, the nation, factory, or individual, who has accepted this law has helped the world forward to better times. In the future, when great decisions have to be made, that nation which accepts this law and the law of unity of control will lead the other nations into straight paths. That Great Britain will continue to lead as it has in the past is certain, providing her sons and daughters are taught these laws, for the origin of these laws is light.

LECTURE II

METHODS OF CHARTING TO CO-ORDINATE DIRECTION AND CONTROL

BEFORE proceeding to the subject of this lecture it is necessary to define the word "chart" and to establish the value of the chart.

A chart is a map. The seaman's chart is a map of the sea, and the value of the chart which the captain of a ship uses provides a parallel for seeing the value that charts may possess to the director of any manufacture.

The captain uses his chart primarily to decide upon a certain course, and in deciding upon this course the chart helps him by pointing out dangers in case the ship should deviate from that course. Having set sail for a certain port, the captain endeavours to keep to that course which he has set, and for that purpose must be provided with means for checking that the ship is on that course. It is not necessary to enlarge on all the various methods adopted to keep on that course and to check position—it is well known how the steering-wheel is, so

to speak, co-ordinated with the chronometer and the position every day marked on the chart—how, as a result, thousands of tons of moving matter are safely directed and controlled.

The value of the first three axioms is so great that it is as well, in passing, to state that they are clearly defined in this example. Thus the captain could not keep on his course for an indefinite time if total darkness existed—*i.e.*, no stars visible and no light on board (Axiom C).

Consider now two parallel questions in connection with direction and control of manufacture. How many directors of manufacture possess charts which enable them to direct and control their business safely? Anyone replying "One in ten" would be suffering from optimism. How many directors of manufacture are there who could hand over the direction and control of their business at twenty-four hours' notice to another director who has never seen their works before; and, moreover, hand it over in absolute confidence that the safety of the business was assured? Anyone replying "One in a hundred" would be suffering from optimism. And the reason for this is that, whereas the captain of a ship must possess certain qualifications, the director of a business need possess none. The captain of a ship must

possess a master's certificate which in itself embraces ability, conduct, and fitness; but to be director of a business no such qualifications are demanded. At the same time qualifications for directorship of any business should be demanded, because life may be lost as easily by inefficient direction in a factory as by inefficient direction from a captain.

Those who read that era-marking publication *The Future*, which was circulated by the Government in the middle of September, 1919, may remember a short article on the "Gospel of Work and Wages." In this article the following words occurred: "I should know for certain that there was a good time coming for the workers if I could learn of men striking because their 'boss' was a poor hand at 'bossing.' Workers simply cannot afford to have inefficient employers."

When in fifteen years' time the history of this "time of the end" of the old world can be seen in true perspective, there is little doubt that the verdict of the historian will be that most of the industrial unrest was due to inability on the part of directors of industry.

Directors to-day are beginning to realize that something parallel to the master's certificate is a necessary qualification for a director,

but it is not only the directors who are beginning to realize this—it is also the workers. Many workers saw the handwriting on the wall in March, 1919, when the Sankey Report was published. The directors were weighed in the balance and found wanting in efficiency. This nation is realizing more and more every day that inefficiency must be rooted out, and that the new world of industry must be built on sure and true foundations—not on the insecure and inefficient foundations of the old world of industry.

Now, the purpose of these lectures is to help; it is to show how efficient direction and control can be developed for any factory or industry. In this lecture it is to show how charts can be developed in order that when the director is weighed in the balance he shall not be found wanting in efficiency. A method of charting must therefore be developed which enables the director to set his course, to show him his position on the course, and to see dangers on that course; and if charts can be kept embodying these three necessary qualifications it will follow that any director can hand over the business to another qualified director at any time without fear of the business suffering.

The charts which a captain uses are built up

on past experience and are the result of past work. Centuries ago men set out on voyages of exploration into the unknown, and recorded the various phenomena with which they came in contact in order that future generations might benefit. These records were gathered together and from the harvest the mariners' charts originated, charts which enable everyone to travel in safety. Thus *the safety of the future depends upon the true records of the past.*

Bearing in mind this parallel, we can turn our attention to manufacture and see how charts can be started for any business, and how the position may be kept up to date on these charts. In any factory the position of work in progress is constantly changing, so that in order to start a chart it is necessary to know the position of that work at the time the chart is started. This must first be obtained in any factory by stocktaking — a usually laborious and costly job, but nevertheless essential. Many firms look upon stocktaking as a necessary evil in order to arrive at the financial position. Stocktaking should be looked upon only as a means of checking the position of work.

Thus the first essential is to obtain the position of work in progress.

In the series of explanatory charts taken for

this lecture a wire-drawing business has been selected, but the same method of charting may be adapted to any business.

In any factory it is necessary first of all to consider what the manufacturer buys in order to obtain his finished product. In the example taken, the wire manufacturer buys billets of steel, which he keeps in stock. He then sends the billets to a rolling mill to be rolled down to coils, which are sent to his works. He then draws these coils down to wire, which he sells. At any time, then, there will be material in the following "zones" or groups: (1) Billets on order; (2) Billets in stock; (3) Billets being rolled down to coils at the rolling mills (material on order); (4) Coils in the works or in process of being drawn down to wire (material in works); (5) Wire in the warehouse. And the direction of "supply" or flow of that material is from billets on order to billets in stock, to rolling mills, to coils, to wire in the warehouse, where the "supply" meets the "demand."

The "demand" may be considered as the other side of the business. It is no use making an article unless someone wants it—there must be a demand; and this demand must be co-ordinated with the supply. Hence it follows that the chart will be incomplete unless there

is a picture of the demand as well as the supply. Now the demand in this case is the total of all unexecuted orders received from customers.

With this introduction the left-hand half of Chart on Fig. 2 may be explained as follows:

Time is plotted horizontally. The unit by which manufacture is measured is plotted vertically. About one-third of the way up on the vertical scale there is a zero line; above this line the "supply" is shown, and below the line "demand" is shown. When this chart was started stock was taken of the five "supply" zones and of the "demand" zone. The chart is shown as starting from the following stock-taking totals. On the supply side:

(1) Billets on order	... ...	1,000 tons
(2) Billets in stock	... ...	2,600 ,,
(3) Material on order	... ...	750 ,,
(4) Material in works	... ...	1,000 ,,
(5) Material in warehouses	... ...	200 ,,
TOTAL	...	5,550 ,,

And on the demand side:

Customers' orders	... ...	2,200 tons

A brief survey of this chart shows that the "Material in warehouse" tonnage is plotted first above the zero line, and the "Material in works" tonnage is plotted above the tonnage

of "Material in warehouse." Thus the material in works plus material in warehouse shows 1,200 tons. The same method of plotting is applied to all the zones.

The charts may now be considered as started, and the next question to decide is how to keep the position up to date. So far it has been shown that direction exists (Axiom A), but movement of material along a line cannot be maintained without control. Hence movement of material must be checked in or out of each zone, and the point at which the material is checked may be termed a "control point" in the line.

The law of unity of control must be applied to these control points—the point, which the material passes, must be known and accepted, and one man must be responsible for recording the quantities which pass. From the records or returns from each of these control points the chart is kept up weekly or monthly, as the case may be.

Now there is one thing which must be considered: Does all the material which is received by each zone go away as good material? Is there any scrap—is there dissembling taking place in any of the operations (Axiom D)? In this example there is dissembling—there is weight lost, for instance, in pickling before

drawing, and if this loss in weight is only 1 per cent. of the weight of matérial it is easy to see that the accumulated error, by disregarding this loss in weight, would amount to 50 per cent. of a week's output in a year.

Hence allowances must be made for these wastes in each zone, and the safest method is to have a return for all scrap despatched, or where there is loss of weight by heating, it is only possible to arrive at the actual loss by applying the law of average from actual tests.

Since this method of charting is new there is placed alongside it the old method of charting which most are accustomed to.

What are the advantages of the new method? Consider a few of the features which can be seen at a glance.

(1) Present position as compared with any time in the past. The safety of the future depends upon the true records of the past.

(2) Liabilities in tonnage as compared with assets in tonnage. The liabilities on the supply side and the assets on the demand side of the chart.

(3) The number of weeks' work ahead, and consequently approximate delivery dates.

(4) The efficient tonnage working level for the works.

(5) General information for dealing with rising or falling markets.

• (6) The investment period for all metal collectively or metal in any zone.

(7) A general comprehensive picture of the position of material.

In the old method of charting none of these features are discernible. Moreover, the old system does not comply with the laws and axioms, whereas the new method does in the following way:

Axiom A is complied with because direction is known—the flow of material, whether from the supply or demand side of the chart, is towards the zero line.

Axioms B and C are complied with, because the lines between the zones are lines generated by periodic movement of the control points; thus a picture of the past is obtained, which throws "light" on the situation and enables decisions concerning the future to be made. In other words, the helm can be altered quickly should the captain sight breakers ahead.

Much could be written about the vision obtainable from these charts. There is one feature which is most important. The chart shows how the growth of one zone must affect the growth in the next—how provision must be

made to accommodate work or material which is certain to come along shortly from another zone, and how each zone relies on its neighbour. This information is so valuable that it is advisable to consider it further.

It will be obvious to all that if in a factory there is not enough work in progress the result will be that some of the operators are waiting at times for work, and the total of these times is fairly considerable. Hence the factory is not working at the maximum efficiency, and it is necessary to push some more work along so as to keep the operators busy. Against this, if the work in progress is congested on the floor of a factory so that it is frequently necessary to move material in order to reach what is wanted then the factory is not working efficiently owing to time being wasted in moving material.

Now one of the most important factors—especially for mass production—from an output point of view is to maintain the right amount of work in progress, and, when charts of the type shown are kept, it is easy to see where pressure is required in order to maintain this correct amount of work—for, when the chart has been running a long time, it will show at what level of material in the works the best production is obtained.

Many engineers are too anxious to get output when starting a new job, with the result that

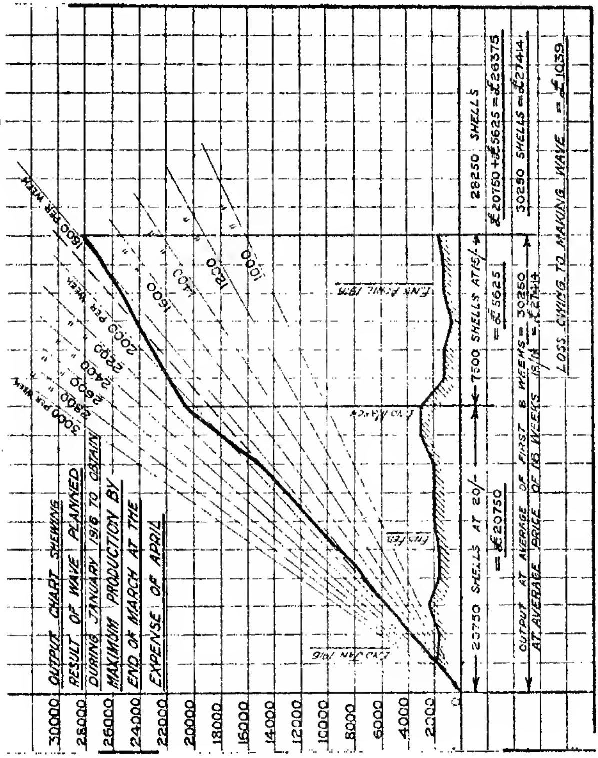

FIG. 3.—DIAGRAM SHOWING RESULT OF WAVE PLANNED.

they keep on " pulling " output off the floor, when in order to increase output they should be " pushing " material on to the floor.

Chart on Fig. 3 is an actual case which occurred during the war, and shows how by increasing production for a couple of weeks at the expense of the work in progress the net result was a loss both financially and in actual output of shells. In this chart the weekly outputs are plotted along the bottom, and the cumulative line above shows how, if the production of the first ten weeks had been maintained for twenty weeks instead of upsetting the floor position, the result would have been an increased output of 2,000 shells and an increased financial return of about £1,000.

Another method of charting which is very useful for comparing such things as input, output, and orders received is shown in Chart on Fig. 4. It is perhaps as well to mention three features of this chart.

(1) When comparing input with output it is necessary to take account of all output—good, bad, and scrap.

(2) When comparing orders received with output it is necessary to compare the orders with the good output only.

(3) The radiating lines supply the average over a period; thus in this Chart orders received are shown as having averaged 250 tons per week over nine weeks.

Financial Direction.—It is now necessary to connect up finance with material. When material is bought money is given in exchange; thus if B is supplied with material by A, the material passes from A to B, and the money from B to A. The line AB is the same in both cases but the flow of material is opposite to the flow of finance; in the same way as we talk of the "up" trains as distinct from the "down" trains so can we talk of "material direction" as distinct from "financial direction."

Now since financial direction is opposite to material direction it follows that, if the material direction is known, the financial direction is also known, and in consequence it is only necessary to convert Chart (Fig. 2) into value of stock and plot money instead of tons, vertically, in order to arrive at a financial direction chart.

Further notes on financial direction will be given in Lecture VI. In the meantime, since financial direction is parallel to material direction, it is only necessary to point out how the Material Direction Chart (Fig. 2) helps the financial director.

In the background of Chart on Fig. 5, the five zones of the supply side of Chart on Fig. 2 are shown, and if these are looked at from the view point of financial direction it is seen that in—

(1) *Billets on order* — the picture shows whether there will be an increase or decrease in the tonnage of billets to be paid for in a month or two months' time. Thus vision into the future is obtained.

(2) *Billets in stock* and (3) *Material on order*— the total shows whether the stock has increased or decreased during the month. If there is an increase it follows that during the month money has been exchanged into billets, and if a decrease then billets have been exchanged into money.

(3) *Material on order*—the picture supplies the same vision into the future as (1), but as applied to material being rolled down at the rolling mills.

(4) *Material in works* and (5) *Material in warehouse*—the total gives the same information as (2) plus (3) but as regards wire.

This information enables the profit or loss to be arrived at for any month in the following way:

Analyze the trading account into headings to correspond with the zones; thus it is only necessary on the demand side to know the value of sales, and on the supply side it is necessary to analyze into four groups—namely, value of payments made (*a*) for billets, (*b*) for rolling, (*c*) for wages, and (*d*) for miscellaneous payments

which cannot be allocated under billets, rolling, or wages. The total of these four groups when subtracted from the value of sales gives a banking account balance, but not a profit. But this balance can be corrected into approximate monthly profit or loss by adding or subtracting the value of the stock increase or decrease during the month, and this stock increase or decrease is supplied by the material direction chart.

A development along these lines for profit or loss is shown in Chart on Fig. 5.

From these few remarks on financial direction it is obvious that material direction when correctly charted supplies the key for financial direction, and that in consequence material direction must be thoroughly understood and grasped before successful financial direction can be obtained. Hence if in a factory financial direction exists which is not co-ordinated with material direction, then a state of dual control is existing in that factory.

LECTURE III

DIRECTION AND CONTROL FOR UNASSEMBLED MANUFACTURES BY EXPOSED RECORDS

WHEN considering the value of charts a parallel was taken from the chart which is used for navigation purposes at sea, and it was shown how the safety of the future depended upon the true records of the past. There was just that one qualification required for the seaman's charts—they must be true, true in every line and figure.

From this parallel a method of charting was developed, so that a director of manufacture could (1) set his course from the chart, (2) see his position on the chart, and (3) see dangers ahead.

Now the value of this chart depended on one thing and one thing only—in just the same way as the value of the seaman's chart depended on one qualification. Everything—from setting the course to seeing dangers ahead—depended on one thing. *The records must be true.* Every engineer who is worthy of the name of

engineer is proud of a piece of work which is true to the limits set; every director and manager is proud of the workman who does the truest work; a real engineer is too proud to allow untrue work to go out of his factory, and when visitors come to see his works he shows them his truest work.

But very, very few directors or managers to-day are proud of their stock or work in progress records. And why? Simply because they are conscious of the fact that they cannot rely upon those records to be true, and this is the sole reason why they are not proud of their records. And yet the safety of the future of that business depends upon the true records of the past.

Now why is it that the records cannot be relied upon? A dozen different answers could be given to this question. One answer might be that directors have spent their lives in studying out better and cheaper methods of manufacture, and consequently have not studied the limit of accuracy of their records to the same extent as they have studied the limit of accuracy demanded in the article which is being manufactured. Another answer might be that records are of secondary importance from the engineer's point of view. But both of these

answers are lamentably weak, because they show that the director has not realized the responsibility of his position.

The best answer to any question is the one which embodies first principles and supplies the cure: and the real answer to this question is that records cannot be relied upon because direction and control are inseparable from light. Bring those records out of that dark cabinet into the daylight and you will begin to think more about them—you will begin to realize that records or figures which are not correct, which are not true, are as much an abomination as a bad piece of work turned out by your workman.

The value of exposed records lies primarily in the fact that they are exposed: exposed to the view of everyone in the works or office, from apprentice to director; exposed in such a form that direction of flow of material and the control points in that line of direction are clear; exposed, because only true records can stand exposure. If you want to kill a lie expose it; if you want to kill lying records, expose them to the full view of everyone. It is absolutely certain death to incorrect and untrue records. And remember—the safety of the future depends upon the true records of the past.

This solution sounds simple, and can never fail, providing the laws and axioms governing direction and control are co-ordinated in the exposure.

In one case where an exposed record system was installed in order to kill incorrect records a complete stocktaking was carried out, and the stocktaking figures entered on the exposed records. Shortly after starting the system inaccuracies of the stocktaking were discovered by the exposed records.

A few months later, at the annual stocktaking, the figures on the exposed record system were not accepted, and the stocktaking figures did not all agree with the exposed records. The supervisor of the exposed records challenged the stocktaking, and proved that the exposed records were correct and that the stocktaking figures again had inaccuracies. At the next annual stocktaking the exposed records were accepted provided the result of auditors' challenges was satisfactory. In no case were the exposed records proved to be more than 2 per cent. out, which was accounted for by the limit of accuracy in the method of counting.

But this result could not have been obtained unless the laws and axioms governing direction and control had been co-ordinated with the

records, for exposure of records in itself only supplies the needs of Axiom C as regards light.

Having now established the fundamental reason for exposed records, it is necessary to consider how the laws and axioms governing direction and control can be applied and co-ordinated in the exposed record system, and although there are no two businesses exactly alike it is advisable to take examples and explain solutions, which embody the requirements of the laws and axioms.

The first example will be one which is similar to that taken for the groundwork of the Material Direction Chart (Fig. 2), and it will show how true information can be supplied in order to keep this chart up to date. The works in this example are engaged in drawing bright bars of different sizes and shapes from black bars of different qualities (*i.e.*, different analysis of materials which had to be kept separate).

An analysis of sales under qualities proved that about 90 per cent. of the output each week could be grouped into either "free cutting" quality or "shafting" quality, and the remaining 10 per cent. embraced a large variety of qualities depending on trade. Now it was considered unlikely that there would be two

different qualities of the same size in the "10 per cent." group being manufactured at the same time, and consequently the complications arising from different qualities were divided into three groups, called the "free cutting," "shafting" and "10 per cent." groups.

An investigation into the number of different shapes or sections into which the bars were drawn resulted in dividing these shapes into three groups, called the "round," "hexagon," and "square" groups.

It was next necessary to find out how many sizes of each shape were manufactured, and here an analysis under sales showed that 95 per cent. of the output would be covered by 150 different sizes. Thus, if provision was made for dealing with a certain amount of bastard sizes, the total number of different articles manufactured only amounted to about 450. In this quantity, however, provision was not made for different lengths of the same size and shape, but this was not of much vital importance, as is explained later.

It was next necessary to consider the direction of flow of material. Orders were first of all sent to the rolling mills, stating quality, size, and quantity required. This constituted a zone, as described in the last lecture. When

material was received from the rôlling mills it came into the works and was weighed—this weighbridge constituted a control point in the line of direction. The material was then under the control of the shop manager, and (according to size) it was necessary for the line of direction of manufacture to be divided into groups, since certain drawing benches were designed for certain ranges of size. The line of direction was therefore decided by size, and an investigation established five groups of sizes or directions, which also constituted costing groups.

After the manufacturing operations were completed the material was sent to the warehouse, and before going into the warehouse it was weighed, and this weighing constituted another control point in the line of direction, which terminated the zone of the shop manager's responsibility.

The finished material was then under the control of the warehouse manager, and remained under his control until it was despatched. This despatching established another control point in the line of direction, and material was then reckoned in the output zone, which belongs to the demand side of the business.

Hence the "supply" direction was divided into three zones: (1) Material on order at

rolling mills; (2) material in works and progress; (3) finished material in warehouse. And the demand side of the business constituted two zones—as shown in Chart on Fig. 2—namely, " output " and " customers' orders."

Thus the problem resolved itself into designing an exposed record control board, which consisted of five zones, and each zone required to have instantaneous up-to-date information stating the tonnage in that zone of material under 150 sizes, three qualities, and three shapes. Further, in one of the five zones there were five directions, which were governed by size. Moreover, the problem could not be considered as solved unless the solution complied with the laws and axioms governing direction and control of manufacture.

Those who are interested in the mathematical aspect of the problem can investigate the various permutations and combinations in questions which may have to be answered at any time of day regarding three qualities, three shapes, 150 sizes, and five zones, one of which is subdivided into five groups; and when they have realized the colossal quantity of questions which can be asked and have to be answered, no further evidence need be given as to the value of a solution which enables one man to keep the

control board up to date, from which he can answer any one of these questions at any time of day.

The solution is shown in Fig. 6, which is one of the three control boards installed at the works of the Halesowen Steel Co., Ltd., near Birmingham.

Provision was made for the various features of the problem in the following way:

The three quality groups—"free cutting," "shafting," and the "10 per cent."—were shown by coloured tickets, white, red, and blue; and the reason for this was that there was a method existing of painting colour on to the end of bars to denote quality. Thus a very excellent and simple method which existed in the works was co-ordinated on the control board.

The three shape groups—"rounds," "hexagons," and "squares"—were separated into three different boards: the photograph shows only the "round" board.

The 150 sizes were arranged horizontally along the boards, spaces being left between every three or four "sizes" for any bastard size which might be ordered. These sizes were also grouped—by leaving an open space between the groups—into the five "draw bench" groups which were governed by size.

The five zones were arranged one above the other—thus all the red, white, and blue tickets along the bottom line showed the tonnage which was on order from the rolling mills, and the total of these figures constitutes the information required for the rolling mill zone on the chart.

The laws and axioms must now be applied, as otherwise the problem cannot be considered as solved.

The main line of flow of material is known to be from the "rolling mills" zone to "shop progress" zone, thence to "warehouse" zone. The "length" of each line—that is the total quantity of tons of each size and quality in each zone—had to be obtained by stock-taking. Thus the length of each line was known, the "length" being measured in tons, which was entered on to the cards on the board.

The control points locating the zones were established by considering the order book for "material ordered from rolling mills" as a control point, the weighbridge into the works as a control point, the weighing into warehouse as a control point, etc. And the law of unity of control was complied with by making one man at each control point responsible for weighing or stating quantity of all material which passed that control point, and for sending

notification of that quantity and size to the control board, which was under the control of one man. Further, there was one man in charge and responsible for the work in each zone. In this way instantaneous, accurate, and up-to-date information was always obtainable concerning any size, shape, or quality, etc., and when true information can be obtained at any minute then decisions can be made or instantaneous action taken.

The law of mutual accommodation is complied with because every record and every figure on the board is of equal importance—one set of figures may be of more importance to one manager than to another, but each is in itself an example of the atom taking up the same amount of space. This is the application of the law materially. The individual or personal application is equally strong. Thus, whoever goes to the board for information can see how he depends on his neighbour and his neighbour depends on him.

In this way are the universal laws and axioms governing all direction and control applied, and it is now only necessary to investigate whether the manufacturing Axiom D has been complied with.

In the operations of bright bar drawing the

black bars are first pickled, and later the ends are prepared for drawing and are cut off after drawing. Both of these operations—pickling and end-cutting—are dissembling, and, consequently, a percentage reduction beyond the actual weight must be made from the works progress zone, when material is moved into the warehouse zone. From the records of the past an average percentage was arrived at from which tables were prepared giving the figure which should be deducted from the works stock (for loss by pickling and ending) when any quantity was moved into the warehouse zone. In this way was the manufacturing axiom complied with and accumulated errors prevented.

There are certain points of detail connected with every exposed record system which may be peculiar to the business, and it is not necessary to mention these, but only such as are common to practically every business. Thus the unit used should wherever possible be the same all over the board—in the example already given the unit used was tons and decimals of tons (for to use tons and cwts. is dual control which leads to inefficiency).

The exposed portion of the ticket on the board was supplied with three columns: the bottom figure in the first column always showed the

amount of material (of the size, shape, and quality) which there was in the zone to which the ticket belonged; in the second column a plus or minus figure was placed; with the date (belonging to that plus or minus) in the third column. When notification was received of material being moved past a control point, the quantity was subtracted from the zone which that control point terminated, and added to the zone which that control point originated—and this is the plus or minus figure which is entered in the middle column.

A brief study of Diagram (Fig. 7) will make this clear. In this diagram two columns are shown on the cards instead of three as mentioned above: thus the record shows that fifty units of part No. 101 were moved past the "stores receiving" control point on December 10, making the stores figure 150 and reducing the "on order" figure to nil.

To take down information for the charts special forms are kept, so that the material can be added up quickly under quality, cost, group, etc. One collecting sheet (see page 60) is used for each zone, and the summary placed on the summary sheet (see page 61) under zones which was extended to cost sheet for wages as shown on page 62.

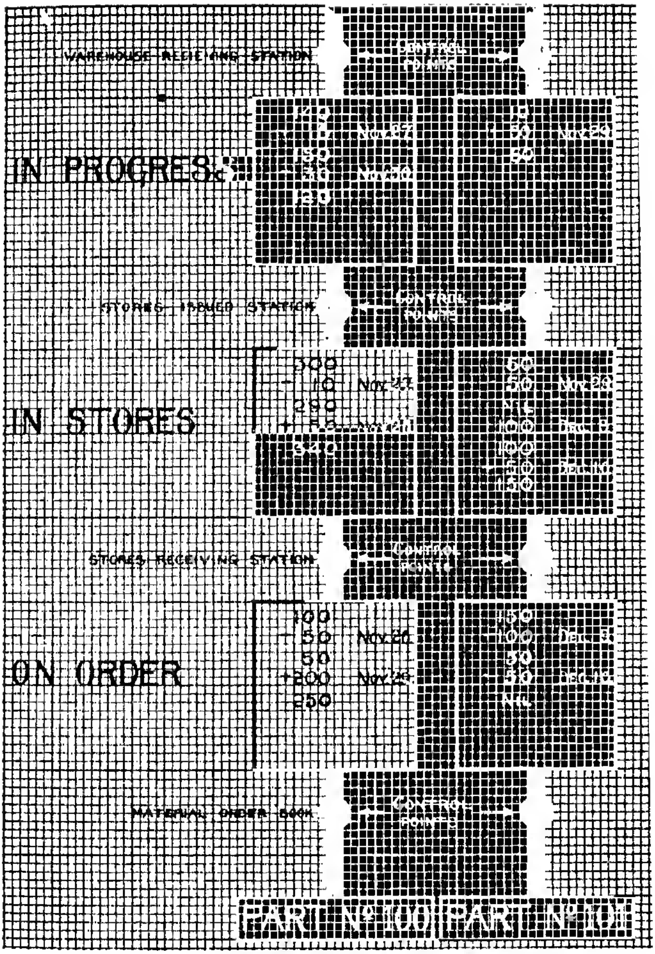

FIG. 7.—DIAGRAM SHOWING METHOD OF KEEPING RECORDS. DIRECTION OF FLOW OF MATERIAL UPWARDS. (FOR DESCRIPTION SEE PAGE 58.)

ZONE........ WEEK ENDING........

ROUNDS

Size	White	Red	Blue	
Inches				
$\frac{3}{16}$				
$\frac{1}{4}$				
$\frac{5}{16}$				
$\frac{3}{8}$				
$\frac{7}{16}$				
$\frac{1}{2}$				
$\frac{9}{16}$				
$\frac{5}{8}$				
$\frac{11}{16}$				
$\frac{3}{4}$				
$\frac{13}{16}$				
$\frac{7}{8}$				
$\frac{15}{16}$				
1				
$1\frac{1}{16}$				
$1\frac{1}{8}$				
$1\frac{3}{16}$				
$1\frac{1}{4}$				
$1\frac{5}{16}$				
$1\frac{3}{8}$				
$1\frac{7}{16}$				
$1\frac{1}{2}$				
$1\frac{9}{16}$				
$1\frac{5}{8}$				
$1\frac{11}{16}$				
$1\frac{3}{4}$				
$1\frac{13}{16}$				
$1\frac{7}{8}$				
$1\frac{15}{16}$				
2				

Size	White	Red	Blue	
Inches				
$2\frac{1}{16}$				
$2\frac{1}{8}$				
$2\frac{3}{16}$				
$2\frac{1}{4}$				
$2\frac{5}{16}$				
$2\frac{3}{8}$				
$2\frac{7}{16}$				
$2\frac{1}{2}$				
$2\frac{9}{16}$				
$2\frac{5}{8}$				
$2\frac{11}{16}$				
$2\frac{3}{4}$				
$2\frac{13}{16}$				
$2\frac{7}{8}$				
$2\frac{15}{16}$				
3				
$3\frac{1}{16}$				
$3\frac{1}{8}$				
$3\frac{3}{16}$				
$3\frac{1}{4}$				
$3\frac{5}{16}$				
$3\frac{3}{8}$				
$3\frac{7}{16}$				
$3\frac{1}{2}$				
$3\frac{9}{16}$				
$3\frac{5}{8}$				
$3\frac{11}{16}$				
$3\frac{3}{4}$				
$3\frac{7}{8}$				
$3\frac{15}{16}$				
4				
$4\frac{1}{8}$				
$4\frac{1}{4}$				
$4\frac{3}{8}$				
$4\frac{1}{2}$				
$4\frac{5}{8}$				
$4\frac{3}{4}$				
$4\frac{7}{8}$				
5				

COLLECTING SHEET. (FOR DESCRIPTION SEE PAGE 58.)

WEEK ENDING ....

SECTION	GROUP	MILLS				STOCK				WAREHOUSE					ORDERS				OUTPUT			
		WHITE	RED	BLUE	TOTAL	WHITE	RED	BLUE	TOTAL	WHITE	RED	BLUE		TOTAL	WHITE	RED	BLUE	TOTAL	WHITE	RED	BLUE	TOTAL
ROUNDS	Inches $\frac{3}{16}$ to $\frac{5}{8}$																					
	$\frac{11}{16}$ to 1																					
	$1\frac{1}{16}$ to 2																					
	$2\frac{1}{16}$ to 3																					
	$3\frac{1}{8}$ to 5																					
HEXAGONS	0·338 to 0·919																					
	1·011 to 1·67																					
	1·860 to 2·758																					
SQUARES	$\frac{3}{16}$ to $\frac{3}{4}$																					
	$7\frac{1}{16}$ to 1																					
	$1\frac{1}{16}$ to $1\frac{1}{4}$																					
	$1\frac{3}{8}$ to 2																					
GRAND TOTAL .. .. ALL SECTIONS																						

SUMMARY SHEET. (FOR DESCRIPTION SEE PAGE 58.)

Section	Group	Output + Warehouse − Warehouse = Works				Total Works	Wages	Cost per	Costing
		This Week	This Week	Last Week	Output	Output per Group	Per Group	Ton per Group	Group
	Inches								
Rounds	$\frac{3}{8}$ to $\frac{5}{8}$								Straightening and Cutting
Squares	$\frac{3}{16}$ to $\frac{3}{8}$								
Rounds	$\frac{11}{16}$ to 1								Small Bench
Hexagons	0·335 to 0·919								
Squares	$\frac{7}{16}$ to 1								
Rounds	$1\frac{1}{16}$ to 2								Double Bench Single Chain
Hexagons	1·011 to 1·67								
Squares	$1\frac{1}{16}$ to $1\frac{3}{4}$								
Rounds	$2\frac{1}{16}$ to 3								Double Bench Double Chain
Hexagons	1·860 to 2·750								
Squares	$1\frac{5}{8}$ to 2								
Rounds	$3\frac{1}{8}$ to 5								Turning
									Total
									All Groups
									Works
									Service

EXTENSION OF SUMMARY SHEET TO WAGES. (FOR DESCRIPTION SEE PAGE 58.)

The savings effected by any exposed record system are numerous: the clerical staff may be reduced; the records can be relied upon; real decisions can be made at any time instead of guesswork decisions; there is saving in time to the director, to the manager, to the foreman, to the staff generally in being able to obtain the information they require quickly at any time without consulting others. Consider in any works without exposed records how long it takes to investigate the position of any one order—how many records have to be turned up, many of which cannot be relied upon and are not up to date. Consider what happens when one man goes to another to get information; it is the exception, rather than the rule, for that information to be supplied without some gossip absolutely irrelevant to the subject coming into the conversation. Many clerks—and even managers and directors—will spend more than 10 per cent. of their time every week in discussing whether a certain horse will win a certain race, or in discussing football or cricket. The exposed record system does not encourage one man to go to another for information—it encourages him to go to the control board for information; and any system which encourages one man to go to another for in-

formation encourages gossip during business hours. Eliminate gossip from the office, and either the staff or the working hours of the staff can be reduced by anything up to 50 per cent., and occasionally more. Gossip does not educate—exposed record systems do; and this education goes on subconsciously, in exactly the same way as it goes on at school in the playing-fields. In the first lecture it was mentioned that the greatest asset for this nation's prosperity was true sport. True records supply a true education, which goes on subconsciously in exactly the same way and acts as an insurance that the business of the nation or factory will be carried on successfully.

In the above example of unassembled manufacture attention was drawn to the fact that no provision was made for showing the lengths of the different sizes and shapes. To have made provision in the exposed records for all lengths of every size and shape would have entailed more work than the value of the information justified. But it was found practicable to record, on the back of the exposed record cards, information respecting the lengths in the warehouse of certain shafts; beyond this, the demand was usually for lengths suitable for automatic machines, since the majority of orders for this

class of material were for machining into various component parts for machines, etc.

In many works the complications, when first analyzed, appear to be so great that the exposed record system seems impossible owing to the space occupied, such as in the following example of a file factory. But further investigation always enables a cutting down of space to be made.

A file factory may be engaged in making files of different types, lengths, and grades of cut from different sections of metal. For example, consider a case of a file factory making fifty different "types" of files, each "type" being supplied in twenty-four different "lengths," and each "length" of each "type" being supplied in five different "grades" of cut. By multiplying the number of "types" by the number of "lengths" by the number of "grades" of cut, the total number of different files manufactured is obtained. In this example the total is 6,000. Consider next the number of different sections of metal used. These may be taken as different for every "type" and "length," but the same for every "grade" of the same "type" and "length." This gives 1,200 different sections of metal used. It is

next necessary to consider the direction of flow of manufacture. The file is an article on which there are a large number of operations, and consequently it is necessary to group these operations and place a foreman in charge of each group—in this example three groups are taken, which may be known as the first, second, and third "progress." Thus the various zones on the supply side are six in number, as follows: (1) Material on order; (2) material in stock; (3) first progress; (4) second progress; (5) third progress; (6) warehouse. And on the demand side two zones must be provided for as in the last example.

Thus this problem may be stated as follows:

An exposed record system is required which consists of eight zones. In two of these zones it is necessary to have instantaneous, up-to-date information, stating the quantity of files which can be made from 1,200 different materials. In the remaining six zones it is necessary to know the individual quantity of 6,000 different files. Further, the solution must embody the laws and axioms governing direction and control.

Thus, in all, 38,400 exposed records would be required; and since the smallest advisable card is 2 inches square, and a certain amount of

space must be left between each, a board would be required at least 300 feet long by 4 feet deep. Now unless something can be done to minimize space it is obvious that the method would be extravagant owing to the time wasted in walking from one end of the board to the other—even supposing space could be found.

The question then is, How can the size of the board be cut down so as to supply the information required, and at the same time comply with the laws and axioms governing direction and control?

Firstly, look at the size of the factory and assume that it is capable of producing an output of 100,000 files per week. It is certain that there would not be a steady demand for each of the 6,000 different files. It is, moreover, a firmly established fact that it is cheapest and most efficient to make a large number of one article at the same time. Mass-production is obviously cheaper than unit-production. In consequence it is necessary to decide upon the minimum number of one sort of file that the factory is prepared to make at one time.

To answer this question scientifically it is necessary to know accurately the decreased cost due to increasing the manufacturing quantity, and for this purpose a cost-quantity

curve is necessary. This curve must be corrected by the warehouse stock investment curve.

A brief explanation of what is meant by the warehouse stock investment curve may be necessary.

If there is £10,000 worth of stock in the warehouse, then there is £10,000 lying idle, which if invested at 5 per cent. would bring in £500 per annum. Thus by holding stock instead of cash the interest is lost, and the greater the stock the greater the investment loss. But the greater the stock manufactured at once the cheaper is the article. Hence there is a point in the combined curves at which the cost begins to rise with the increasing quantity, and this point locates the economical manufacturing quantity. This is the scientific way of arriving at the minimum number of one sort of article which should be manufactured by mass-production; but since this curve does not drop or rise fast, the limit is fairly elastic.

Reverting to the file factory, consider that a minimum manufacturing quantity of 500 files has been decided upon. Further, assume that the average time for 500 files to pass through all stages of manufacture—from raw material, etc., to warehouse—is a fortnight. It follows that if 500 files is the minimum manufacturing

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quantity and the output per week 100,000, there cannot be more than 400 orders in progress at once. Consequently, out of 6,000 different files only 400 are being manufactured at the same time. Hence for the exposed records of progress in the shop and for shop output it is possible by eliminating empty records to reduce the 300 feet length of board to about 20 feet.

But this only applies to four of the eight zones. As regards the other zones—the "material on order" and "material in stock" must each have 1,200 records—*i.e.*, one record for each size of material. The "warehouse stock" zone and the "customers' orders" zone require 6,000 exposed records.

Hence the total number of exposed records required, which was originally shown as 38,400, has been reduced to about 16,000.

Analysis of sales of the past can then be considered, and this is certain to eliminate a big percentage of lengths of some types which have never been manufactured, and for which provision need not be made in the exposed records. A solution by exposed records for this problem is shown in Diagram (Fig. 8). In this, orders are shown as being collected firstly under "type"—each "type" having a section of the collecting board to itself.

Types I. and II. only are shown in the diagram. These orders are then entered on the card, which locates the "length" vertically and "grade" of cut horizontally.

This board can also be arranged (although it is not shown in this plate) to have the "warehouse stock" record alongside the "customers' orders" record. The plate shows how "material on order" and "in stock" is shown on this board.

Board No. 2 shows the work in progress, and is connected to Board No. 1 by symbols; thus Type I., 4 inches long, Grade 1, is Symbol I.—4—1; and the design of this board is such that the numerical order of the symbols may be preserved along the length of the board.

In this example the laws and axioms may be applied in practically the same way as in the first example.

The unit used for this board should be quantity, and it is advisable to convert the material weight into quantity of files which can be made. By so doing all the complications, from applying the Axiom D, are eliminated.

This example of the file factory* has been

* Since writing the above an exposed record system, similar to this example, has been installed at the file factory of Messrs. T. Firth and Sons, Ltd., Sheffield.

chosen with the object of explaining how a particular type of manufacture may at first sight appear too complicated for exposed records, and how the difficulties are overcome. It must be remembered that those records must be kept somewhere, and the result of co-ordinating the complete lot must result in considerable saving in time and money, and consequently increase the efficiency of the factory.

The solution for most factories making unassembled articles would in all probability be far simpler, because it is unlikely that the total number of necessary records would be so high as in this example.

LECTURE IV

DIRECTION AND CONTROL FOR ASSEMBLED MANUFACTURES BY EXPOSED RECORDS: BALANCING

HAVING now dealt with unassembled manufactures by exposed records, it is necessary to consider how to co-ordinate this system with the final product, when those unassembled parts have to be assembled.

Again, although there are no two businesses exactly alike, it is advisable to take examples and explain solutions, which embody the requirements of the laws and axioms governing direction and control. For if the student cannot learn by parallel, then he must either commence to learn in this way or stop studying.

The two examples of assembled manufacture to be explained are very different types of assembly.

The first example is the manufacture of safes —a slow-moving type of assembly, and, moreover, an article which requires a large number of parts to make up the finished article.

The second example is that of power-trans-

mission chains, which can be reckoned as quick moving and one in which the number of parts to make the finished article is small.

Now, whether dealing with mass-production for a standardized chain or simple production for a standardized safe, the same laws and axioms governing direction and control must apply.

If the article which is being manufactured is not standardized, then the problem is different, but the laws and axioms must still be applied; and the method of dealing with articles which cannot be standardized is dealt with in Lecture V.

A safe is an article which is composed of anything up to 300 different component parts, according to the size and quality. In this example there are twenty-seven different sizes or qualities of standardized safes. Some of the component parts may be used for only one safe; some may be used for any number up to twenty-seven; some may be used in different quantities for the different safes. Moreover, when an article is standardized, the component parts are standardized, and any factory may use some of these standardized component parts for a non-standard article. Hence the problem

undoubtedly possesses complications which do not arise in unassembled manufacture.

If an article is standardized it may be assumed that there is an inventory in some shape or form which states the name, number, size, and metal used for each component part that is required for the completed article.

From these inventories an analysis can be made—and this analysis should be made from the beginning of the supply side of the business, or, in other words, from the material ordered for making the various component parts which are required for the finished article. The analysis should therefore be divided into three sections: (1) MATERIAL ordered for (2) MANUFACTURING the component parts required for the (3) FINISHED ARTICLE.

In this example, analysis of the safe problem revealed the fact that about 90 per cent. of the weight or value of raw material required for each safe could be considered as the manufactured component parts, and the remaining 10 per cent. was composed of such things as rivets, screws, etc.—parts which could be quite easily controlled by a visible stock-level system (see Lecture V.).

In making the analysis from which the 90 per cent. figure was arrived at an imaginary

programme of manufacture was taken, which was based on the records of sales of each type of safe in the past. True records upon which the safety of the future depended—for it is certain that the records of sales of the past will always supply a safer basis for the prospective trade of the future than guesswork will, providing that the article is standardized—for standardization implies that the demand will be fairly steady.

When analyzing, the material section of the analysis was divided into ten different material groups, such as ½-inch boiler-plate group, 14-gauge case-plate group, etc.

These ten groups of material were used for a total of twenty-seven differently named groups of component parts which were manufactured in varying sizes according to the size of safe in which they were used.

Each of these ten groups of material and twenty-seven groups of component parts were in turn analyzed down to the number of different sizes of material ordered or component parts made.

Before turning to the photographs of the actual exposed record system installed at the works of the Chatwood Safe Co., Ltd., Bolton—for this example is an explanation of an actual

case in operation—it is advisable to consider a simple form of exposed record board for this class of assembled manufacture.

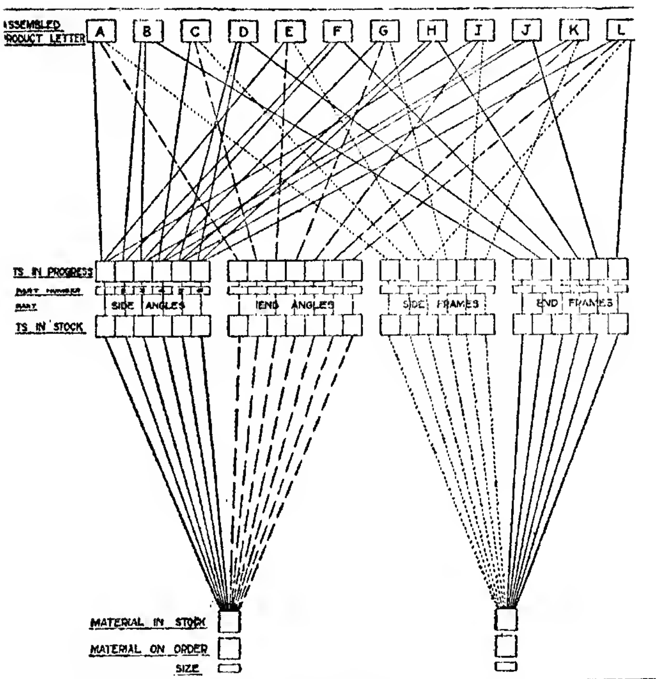


FIG. 9.—GENERAL ARRANGEMENT OF EXPOSED RECORDS FOR EXPLANATORY PURPOSES.

In the explanatory diagram (Fig. 9) direction of flow of material is from the bottom to the top; thus at the bottom there are two sizes of

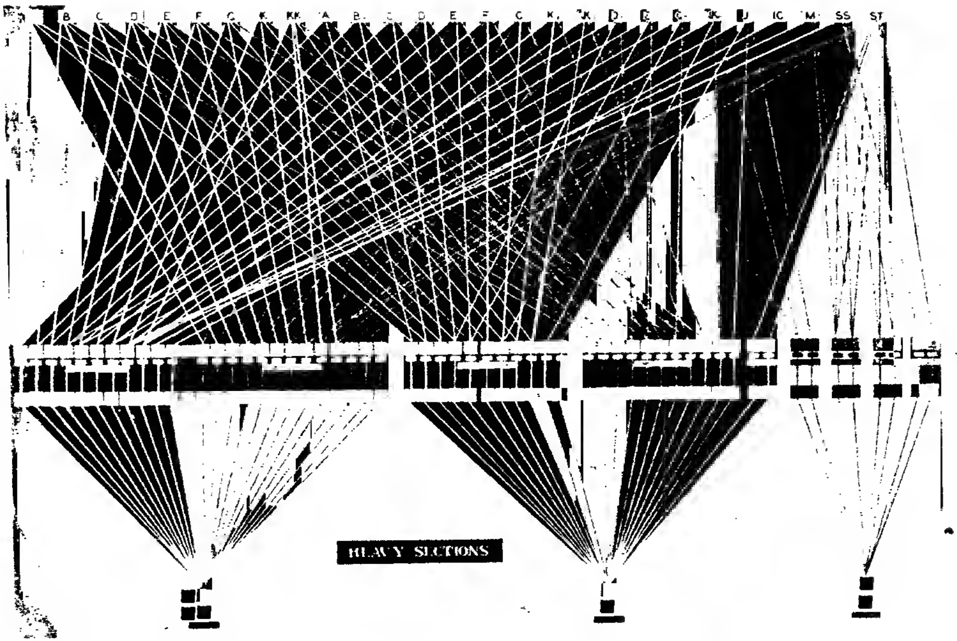


FIG. 10. CONTROL BOARD AT MESSRS. CHATWOOD SAFE CO., LTD., BOLTON. (FOR

material shown (in this case angle-iron). One size flows to the component parts (in the manufacturing section) called "side" and "end angles," and the other size flows to the component parts called "side frames" and "end frames." The direction of flow from these component parts is towards the letters at the top of the diagram—thus No 2 "side angle" component part flows to letters *B* and *F*, these letters representing different standardized safes.

This brief explanation will enable the photograph (Fig. 10) of the Heavy Sections Board to be understood. This is divided into the three main sections of the analysis: material along the bottom, manufacturing along the centre, and the finished article along the top. These three sectional divisions are connected by lines. In practice different coloured ribbons are used for each group of component parts, as is shown in the coloured illustration (Fig. 11). Different coloured record cards are also used; thus all green tickets denoted work in progress, all pink tickets work in stock, and all white tickets material on order. This colouring of tickets was common to all the four boards installed.

Colour must never be lost sight of when exposed records are installed—for, as Ruskin

says, "of all God's gifts to the sight of man, colour is the holiest, the most divine, and the most solemn." What would the midsummer garden be like if the rose, the grass, the viola, and the other component parts possessed no colour? The garden would be as uninspiring and depressing as a November fog.

A further explanation of this photograph (Fig. 10) may be given by applying the axioms.

Direction is known. The flow is upwards. Material is ordered in lengths of 20 to 30 feet; the bottom record card shows how many feet of that material is on order. Material then comes into the works store; the record card above the bottom card shows how many feet of that material is in the works store. This feetage, under the supervision of the storekeeper, may then be cut up into varying lengths, in which case the quantity of each of those lengths is shown on the lower card of the manufacturing or centre section of the board. These lengths are then issued out for a certain safe to be manufactured; the upper record card of the manufacturing section shows how many of these lengths there are in the works being assembled, and the ribbons from this ticket lead to a letter which shows into which safe or safes those lengths are assembled.

DATE.................. POSITION.................. SAFES ON ORDER..................

SAFES AUTHORZIED ....

BOARD	½ BOILER PLATE								MISCELLANEOUS							HEAVY SECTION						CASE PLATES		
GROUP	Body Plates	Back Plates	Door Plates Inner	Door Plates Outer	Inner Body Back	Inner Body Sides	Inner Body Ends		Bands	Centres	Iron and Steel Plates	COMPO PLATES Door Plates	COMPO PLATES INNER BODY Back	COMPO PLATES INNER BODY Ends	COMPO PLATES INNER BODY Sides	LOCK CASE T Side	LOCK CASE T End	ANGLE FRAME Side	ANGLE FRAME End	LOCK CASE L Side	LOCK CASE L	Side	Back and Ends	Chamber B. & C.
NO. PER SAFE																								
IN WORK																								
IN STOCK																								
ON ORDER																								
TOTAL																feet		feet		feet				
ALSO USED ON .. -																								
MATERIAL																								
SIZE																								
WEIGHT PER UNIT																								

REMARKS:

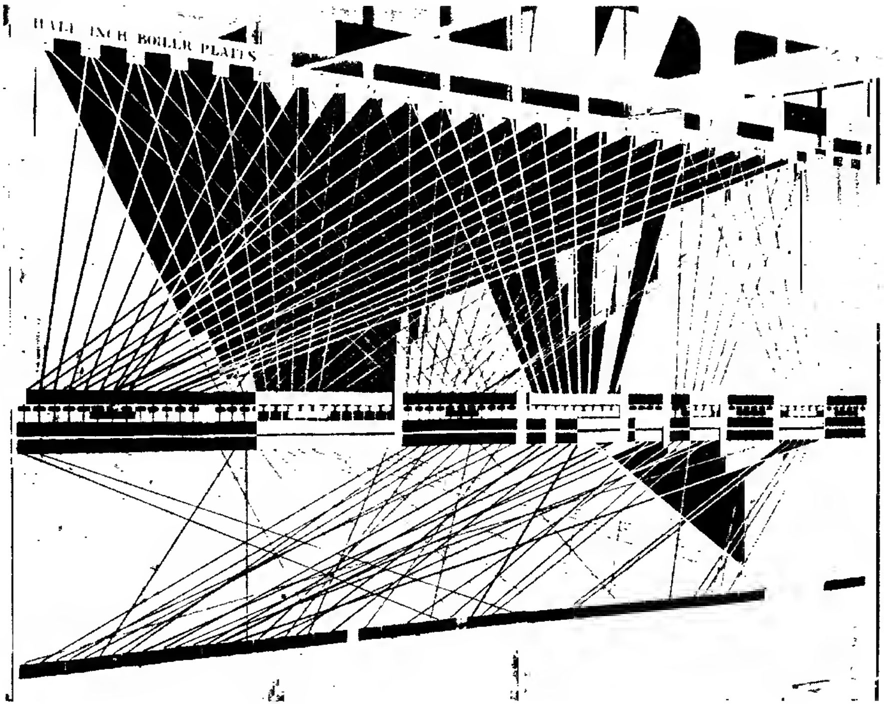
POSITION OF WORK FORM. (FOR DESCRIPTION SEE PAGE 89.)

Immediately below the upper record card in the manufacturing section of the board there is a small card fixed, which states (1) the length of the component part and (2) the quantity of those component parts required for the safe in which it is assembled. This enables the controller (1) to make the necessary deduction in feetage when lengths of material are cut up into the component part lengths, and (2) to subtract the correct number of parts from the works record card when a safe is despatched.

Control points to decide the line were also established. Thus, when material was issued from stores to works, the issue note had to pass the control board and receive the control board stamp, which was evidence that the move had been noted by the controller and the figures altered. In other respects the first three axioms were complied with in the same way as mentioned in the last lecture.

As regards the manufacturing Axiom D the quantity of parts was kept on the board, and not weight of parts; hence any dissembling of material which went on during machining operations did not affect the figures on the board.

In the ½-inch boiler-plate board (Fig. 12)


HALF INCH BOILER PLATES

plates were ordered of the size required for each safe; hence the "on order," "stores," and "in progress" quantities were shown in the middle or manufacturing section of the board. The bottom line was supplied to enable mass-production to be introduced at a later date—for with mass-production it is always advisable to reduce as far as possible the number of sizes of material ordered, and thus reduce the investment on raw material.

In the coloured illustration (Fig. 11) the case-plate board is shown. Two different gauges of plates were used, and these were divided in the material or bottom section of the board. In other respects this board was similar to the boiler-plate board.

The fourth board (Fig. 13) included those parts of the 90 per cent. analysis which were not included in the other three boards. At first sight there appears to be a fair amount of congestion in the lines leading to the centre letters at the top of the board—but each and all of these lines was perfectly clear to the operator, because, firstly, a different coloured ribbon was used for each component part group, and, secondly, the board is designed so that the controller's or operator's eye is on a level with the centre of the board, and direction is

always clear when the eye is in line with the direction of a ribbon.

Balancing.

It is now necessary to consider a most important point, which requires to be constantly watched in any assembled product factory.

Everyone who has had experience with assembled manufacture knows how delays occur in assembling because one small and inexpensive component part has been overlooked, or is behind time, or is not in stock.

Several motor-cars may be held up because one small part for each, perhaps only worth half-crown, is out of stock. During the war hundreds of thousands of fuses were held up in assembling because one small and inexpensive part was behind time. The waste of time from this lack of balance is felt in many ways: the workmen may have to be put on to other work and the job stopped until the missing part arrives; the works manager wastes time in speeding up that part or in trying to discover who is to blame; the buyer wastes time in trying to purchase; the customer wastes time in complaining of bad delivery; the director wastes time in trying to explain away bad deliveries or in holding post-mortems on the cause of the

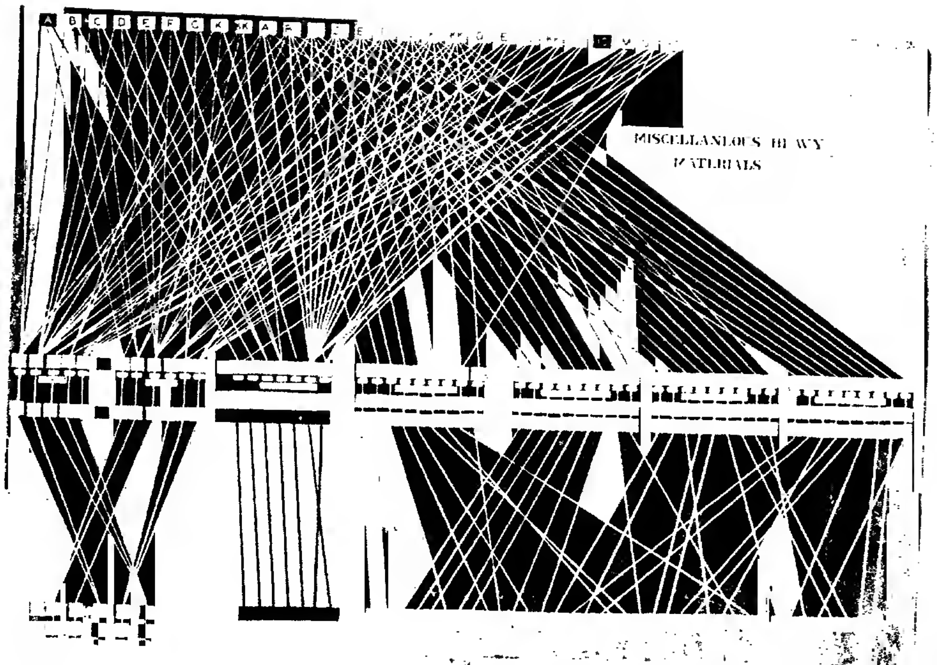


FIG. 13. PHOTOGRAPH OF CONTROL BOARD AT MESSRS. CHATWOOD SAFE CO., LTD., BOLTON. (FOR DESCRIPTION, SEE PAGE 81.)

delay; and during the war Members of Parliament wasted time by asking questions concerning the cause of the delay, and in listening to replies which were valueless and had caused more waste of time.

The accumulated total of all the waste of time, caused by some small articles of insignificant value, which is going on in this country to-day and has been going on for years and years, is so colossal that one cannot even hazard a guess at the number of millions of pounds that is being wasted in this country every year. And all because the directors and managers of assembled manufactures do not know how to keep their stocks in balance.

The number of firms in this country to-day who can say truthfully that their stocks are in balance is infinitesimal. Begin to get those stocks in balance, and what happens? In one case, within a fortnight of installing an exposed record system, which enabled balancing to be established, the output jumped up 50 per cent., and was maintained at this level until the parts were in balance. Bringing stocks into balance means that only those component parts are manufactured which are required to release the finished product lying in the warehouse. In this case the 50 per cent. increased output

was obtained for over a year, and the profit made through this increase was a higher figure than many directors retire upon.

Balance in a sphere exists because all the lines from the centre to the surface are of equal length. Balance of component parts can be maintained by keeping the length of all the lines the same.

Now look at the solution of this problem of how to keep stocks in balance, or, in other words, how to keep the length of all the lines equal. Look at the simplicity of the solution to a problem which is worth millions of pounds to this country every year, and look first at the reason of the simplicity of the solution! Exposed and up-to-date records, in which the universal laws and axioms governing all direction and control are accepted unconditionally. That is the sole reason for the simplicity of the solution which is now given.

In order to get stocks of component parts in balance it is essential to have accurate and up-to-date information, and to be able to put this information down upon balancing forms. A portion of one of the forms for the safe problem example is shown on Fig. 14.

The first column gives the size of material.

The second column gives the name of the

component part or parts manufactured from that material.

The third column gives the letter of the standard safe for which that part is used. In

HEAVY SECTION BOARD (TEES)

SIZE OF MATL.	GROUP	SAFE	Nº FOR PROG	Nº PER SFE.	REQ? FOR PROG.	WORKS STOCK	BAL. REQ?	LENGTH (FEET)	FEET REQ?	FEET STOCK	REMARKS
4×4×½	END TEE LOCK-CASE	G	5	2	10	5	30	2·26	67·80		
		GS	10	2	20	25					
		GT	15	2	30	—					
					60	30					
	"	K	5	2	10	16	40	2·67	106·80		
		KS	3	2	6	24					
		M	15	2	30	—					
		SS	7	2	14	—					
		ST	10	2	20	—					
					80	40					
	"	KK	10	2	20	9	33	1·66	54·78		
		KKS	5	2	10	28					
		KKT	20	2	40	—					
					70	37					
	"	KK	10	2	20	15	40	1·60	64·00		
		KKS	5	2	10	15					
		KKT	20	2	40	—					
					70	30					
	"	JT	5	2	10	15	-10	2·02	—	20·20	
					—	5					
					10	20					
	"	JT	5	2	10	14	-10	1·97	—	19·40	
					—	6					
					10	20					
	"	IC	50	2	100	55	30	1·55	46·50		
					—	15					
					100	70					
								TOTAL	339·83	39·90	

LESS MATERIAL (4×4×½) IN STOCK & ON ORDER 120 *ft.*

NET TOTAL FEETAGE REQUIRED 219·88 *ft.*

TONNAGE REQUIRED (F×12·78 *lbs*) / (2240) *1·25 Tons*

FIG. 14.—BALANCING.

the fourth column it is necessary to enter the quantity of each type of standard safe against which it is decided to balance stock.

In the fifth column the quantity of component

parts used for each safe is given, which, multiplied by the fourth column, gives the quantity required for programme.

This quantity is entered in the sixth column.

In the seventh column it is necessary to enter from the exposed records the quantity of those component parts that exist in the works or in stock (also quantity on order for cases where the material is ordered of the size of the component parts, such as boiler-plates, already mentioned).

The total of the seventh column figure subtracted from the sixth column total gives the figure in the eighth column—namely, quantity required to balance against programme.

The ninth column shows the lengths of these component parts, so that by multiplying this length by the figure in the eighth column the balance required is converted to feetage, which is entered in the tenth column.

If the figure in column eight is a minus quantity, then the conversion to feetage should be entered in the eleventh column.

Columns 10 and 11 are then added up. The feetage of material in stock and on order is subtracted, and the net total feetage required is obtained, which is converted into tons.

A brief study of the extensions of figures (in

Fig. 14) will enable the student to grasp this explanation. Thus to balance it is necessary, firstly, to have a schedule or programme to balance against which quantity is entered in the fourth column. Secondly, it is necessary to know the quantity in works, in stock, etc., and to be able to obtain this information in a few minutes. This the exposed records supply, and if a system is such that this information cannot be supplied accurately and instantaneously, then it is impossible to obtain and maintain a true balance.

Thus exposed records solve this otherwise insoluble problem—and the solution involves only the simplest arithmetic which the most junior member of the staff can do.

The value of this solution to this nation alone in the future in interest on money saved may be reckoned as millions of pounds every year. But this is the mercenary point of view. The real value to the nation and to the whole world may be summed up in three words: "Truth will flourish."

Exposed records, symbolizing truth, in which the universal laws governing direction and control are accepted unconditionally, will lead the nation to greater efforts.

The phrase "exposed records" must not be

taken in the narrow interpretation given in these lectures; this is but one of numberless interpretations of the first principle—light: but it is a practical interpretation, and, as such, one which appeals to the practical man.

The next problem which requires a solution is in regard to co-ordinating charts with assembled manufacture.

At first sight it would appear that a large number of component parts must require a large number of charts; *but if the component parts are in balance,* then a chart of one group of parts supplies a picture of all the groups, for things which are equal to the same thing are equal to one another.

In the example under discussion, the boiler plates were the heaviest and most expensive item, and, in order to chart, it is only necessary to collect information from the zones on the boiler-plate board and convert this information to the unit required for the chart.

There is one other form for collecting information which must be mentioned (see page 79).

To enable the works manager to concentrate on those component parts which are most behind time it is necessary that he should have a picture

of the position of work for the article under consideration. For this purpose a work position form, portion of which is shown in Fig. 15, is filled up from the board when required. This

BOARD.	CASE PLATES.			¾" BOILER PLATE.				
GROUP.	Side.	Back and Ends.	Chamber B &C.	Body Plates.	Back Plates.	Door Plates Inner.	Door Plates Outer.	Inner Body Back.
No. per Safe								
In Work								
In Stock								
On Order								
Total								
Also Used on								
Material .. .. .. Size								
Weight per Unit								

FIG. 15.—PORTION OF POSITION-OF-WORK FORM.

form supplies full information about the component parts for any particular safe, including information as to the number of each of the component parts used for that safe and on what other safes the same component parts are used.

With this accurate information before him the works manager can quickly see which parts require his first attention.

These two forms—the balancing form and the position-of-work form—are further used by the planning department, as is mentioned in the next lecture.

The object in giving a full explanation of this example of assembled manufacture is to supply the student with a parallel for the type of assembled manufacture for which he requires exposed records. To give a list of assembled manufactures is not necessary, but it is perhaps as well to mention that considerably more than half the factories of the world are engaged in assembled manufacture. Look at the agricultural machines trade, the motor-car and cycle trade, or the textile trade, the press; or consider such articles as boots, pianos, sewing-machines, telephones, kitchen-ranges, knives—in fact any standardized article which has more than one component part. In each one of these trades balance is lacking, and material or parts which should be in balance cannot be kept in balance unless the man in charge knows how to maintain balance.

The baby learns to balance before he can walk, and not even kings can reverse this order of

nature; hence until the manufacturer knows how to keep his stocks and work in progress balanced he must expect to employ four legs where two are sufficient.

A somewhat full explanation has been given to this first example because in many respects the problem embraced a condition of affairs which is fairly general in the manufacturing world to-day. This condition of affairs may be looked upon as the switching-over period from standardization to mass-production.

It is now necessary to explain briefly how direction and control were co-ordinated in the mass-production example of manufacturing power-transmission chains.

The explanatory diagram (Fig. 16) shows an exposed record system for ten chains lettered A to J.

These chains—like the bicycle chain—each have five component parts—namely, inner links, outer links, rivets, bushes, and rollers.

The links being flat are manufactured from a flat material, while the rivets, bushes, and rollers are manufactured from round material.

In the diagram Fig. 16 direction of flow of material is upwards, and it is easy to see that some of the materials are used for more than

one component part, and that some of these component parts are used for more than one chain.

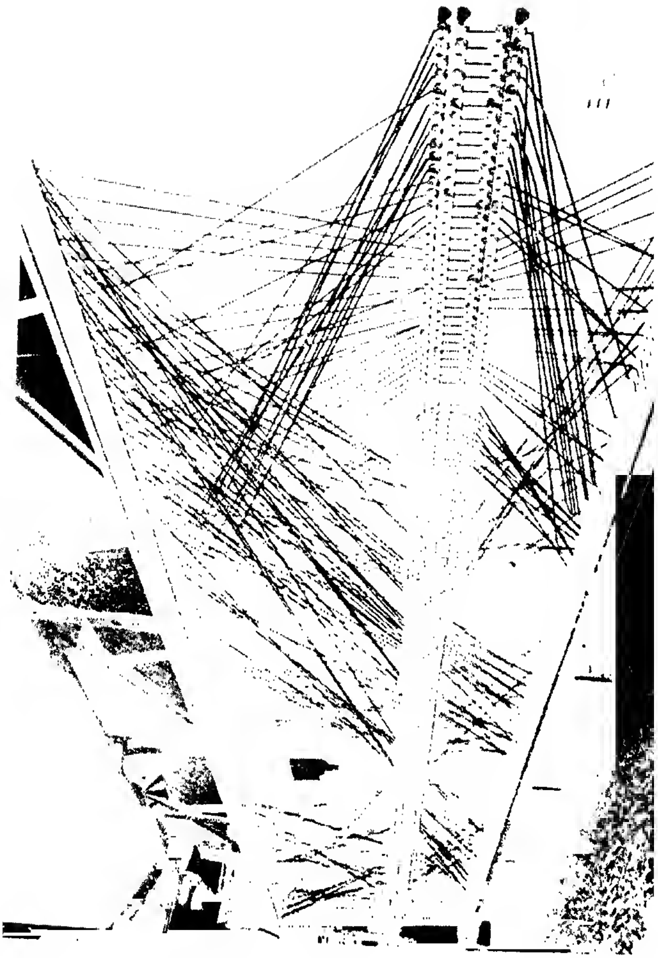
The centre or manufacturing portion of the board is the same as the type of board used for unassembled manufacture, because at this period of manufacture the unit is being manufactured.

From the method of balancing given in the previous example the student should be able to develop from this diagram a balancing form, and also draw out a position-of-work form.

A brief explanation can now be given of the exposed record system installed at the works of Messrs. Hans Renold, Ltd., Manchester.

Photograph on Fig. 17 shows this board. The near half of this board shows the component parts manufactured from round material for fifty-eight standard chains. These component parts, the rivets (or studs), bushes, and rollers, were separated, and different coloured ribbons were used to show the line of direction of flow of material.

The height of the centre or manufacturing section of the board was about level with the eye, so that there was no confusion of lines such as exists in the photograph. The student can test this on the coloured plate by placing his



eye in the line of direction of any apparently confused line. Having explained fully the balancing and position-of-work forms in the previous example, it is not necessary to develop these now; but it is perhaps as well to mention that balancing of this board could be carried out easily by two men in four hours, and this balancing included the balancing of parts and metal.

Right throughout this board the laws and axioms governing direction and control were subconsciously applied, for these laws and axioms have not been consciously applied until the latter half of the year 1919, whereas this board was installed in the early months of 1917. Thus the board from a normal development point of view was "born out of time," or premature, and the subconscious laws and axioms could not be taught as they now can be.

From the application of the axioms in the previous examples, the student can now see how these did apply; but it is perhaps as well to explain how the two laws were applied.

In the centre of the board a bell was placed, which could be rung by any of the departments. The superintendent in charge of the board had on the staff three or four traffic porters, and the

duty of these porters was to go to any department, when the bell rang, and take the material or parts waiting for removal to the next department in the line of direction. These traffic porters had to take this material (in nearly every case) via the control board so that the quantity marked on the move ticket could be verified. In a few cases this verification was done by the traffic porter without moving the material past the official verifier.

Thus all the control points in the line of direction were co-ordinated under one transport control, and the figures on the board were correct within half an hour of the actual move. The law of Unity of Control was thus complied with.

The law of mutual accommodation as applied to the material and parts is as obvious as in previous examples. As regards its application to the individual it is only necessary to add that if the factories of this country could have seen and heard what the author saw and heard increasing in volume in those works month by month; if they could have seen the silent growth of mutual accommodation, trust, and confidence among those workers, and heard that ever-increasing true ring of the true heart of the British workman doing true work, whether

engaged in an administrative capacity or in riveting up chains: then one and all would know that the solution for industrial unrest lay, not in building up endless stories on insecure structures, but in starting to build the new world of manufacture from true records, in its widest interpretation.

LECTURE V

DIRECTION AND CONTROL FOR MISCELLANEOUS MANUFACTURES: PLANNING AND STOREKEEPING

IN the exposed record systems so far discussed the manufactures were standardized —the works in each case were manufacturing the same articles day after day and year after year. But in each case provision was made for adding more articles should the demand arise at any time.

Thus, in the exposed records for the wire-drawing and bright bar business, provision was made for dealing with any odd sizes that might be ordered.

In the solution given for a file factory, provision could also be made for any special order for files if the quantity justified inclusion in the exposed record.

In the examples discussed in the last lecture provision could always be made for dealing with any extra safes or chains should the demand justify the inclusion.

In the case of chains, the original board has

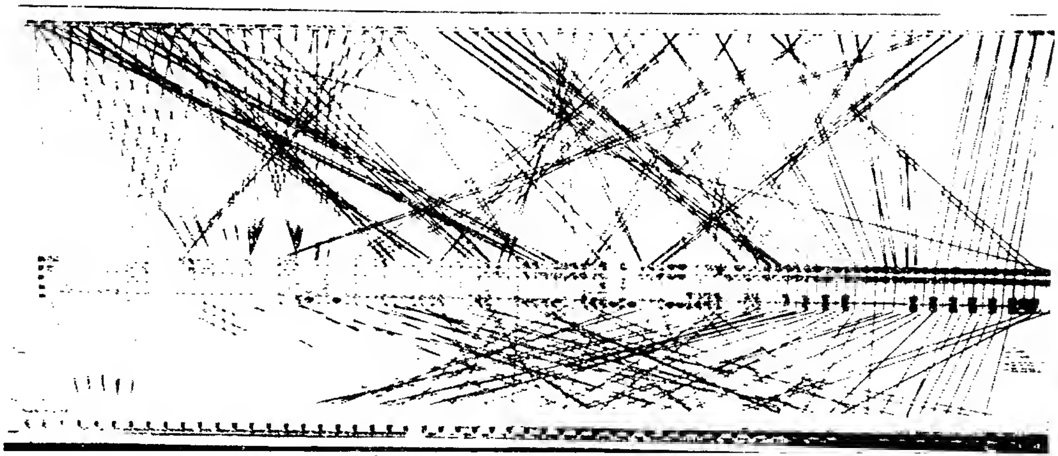


FIG. 18. EXPOSED RECORD BOARD.

To face p. 67.

been altered several times since photographs Figs. 17 and 18 were taken: the number of standard chains dealt with now by this board is considerably less than it was when the board was installed; but the value of the exposed record system has been so enormous that departmental boards are now in operation.

This reduction in number of standards should always be aimed at, because the manufacturing problem is simplified in proportion to the reduction of standard articles manufactured.

It is now necessary to consider what is meant or implied by standardization: The whole of a trade may combine and fix the dimensions and limits of a standard article; and when trades combine it is usually in order to apply the law of mutual accommodation to the user or to supply the demand from the user. Thus cycle chains may be standardized so that, in the event of a breakdown, the user can get a replace at the nearest shop. In the case of such things as bolts, rivets, etc., there is the same value in standardization to the user, for it does not affect him whether the bolt he uses is made in England or Scotland so long as it is standard and interchangeable with the bolts which he has used before.

This standardization in the trade as a whole

is very necessary for certain articles; but there are several articles from which the user obtains no benefit in standardization except in the question of price, and these articles include such trades as cutlery. But just because the user does not force standardization upon the trade there is no reason whatever why any firm in the trade should not standardize some of their articles, for the result of only manufacturing a few articles instead of many must be a reduction in cost and increase in output.

Consider a case as follows: Suppose there are ten manufacturers of pocket-knives who decide to make twenty pocket-knives of the type and size which, from their individual sales of the past they find that there has been most demand for. The result to the user is that there are still 200 different pocket-knives to choose from, and if he cannot get suited with this choice then he belongs to a freak minority which should not be catered for by firms who are anxious to increase output and reduce cost.

But it is not the actual user—the general public—who is to blame for the large amount of sizes and ranges of pocket-knives made; it is the wholesale buyer, who for years and years has given a totally erroneous impression of salesmanship to the manufacturer. If any

manufacturer to-day travelled round the country with twenty samples of pocket-knives which he guaranteed to keep always in stock and to supply at a lower price than he had before, then he would know within a few weeks that those pocket-knives were his standard articles.

Now in every factory there are a certain amount of articles which cannot be standardized, and such may, even after standardization has been carried as far as possible, be quite a useful percentage of the business; and, moreover, a necessary portion of the business for increasing the trade of the standardized articles —such, for instance, as wheels or clutches for a chain drive, in which the chain is standardized. Now it is just as necessary to be able to direct and control these miscellaneous articles as it is to direct and control the standardized articles.

In the exposed record systems already described there was a visible direction of the flow of material, and this visible direction was possible because the article—and consequently the direction of the article—was standardized; but in the miscellaneous manufacture this direction cannot always be standardized because the operations required vary with every different article. And yet the laws and axioms must be

applied, for efficient direction and control cannot exist unless these laws and axioms are applied. Hence it is necessary to find another solution, and to find this solution it is necessary to consider the origin of the order.

In the majority of cases the order for that article originates with an inquiry, and that inquiry usually asks for the price and earliest delivery date. To answer that inquiry honestly and conscientiously the manufacturer must know if he can make the article, how to make it, how long it will take to make, and how much work has priority in promises before he can start to make it; and all except this last question can be answered by writing the order of operations and estimating the time on each operation. Now in every works the number of operations which can be carried out by the operators with the machines or by handicraft is known, and someone in those works knows the operations which have to be carried out to any article which is going to be manufactured in those works; also in nearly every article which is made in those works there is a delivery promise given, and if that firm wants to hold up its head it must keep its promises.

Thus for any article for which an order is received there are two things which must be

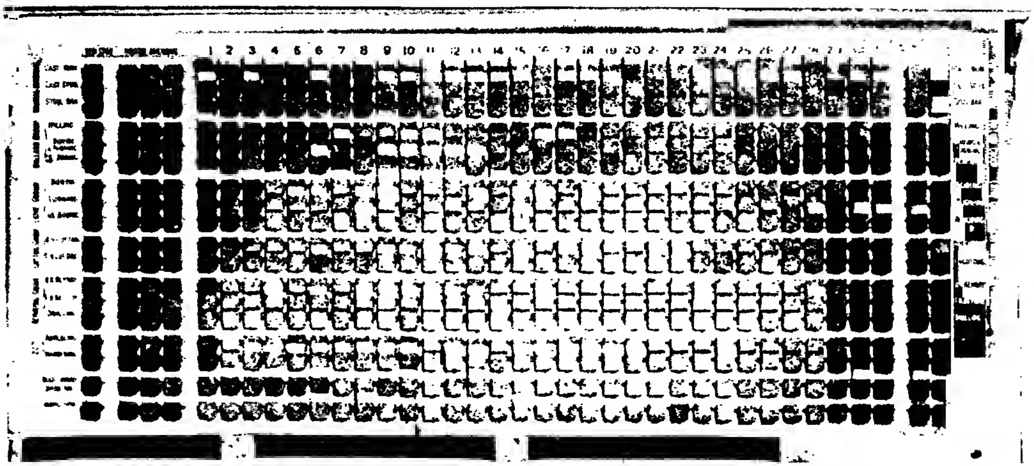


FIG. 39.—POCKET BOARD OF MESSRS. HANS RENOLD, LTD., MANCHESTER.

To face p. 107.

co-ordinated—namely, the order of the operations (which is direction of flow of material) and time (in order that the promises may be kept).

Consider a simple article, such as a cast-iron machined wheel, which is ordered from a millwright who has promised delivery in three weeks. The order of operations may be—(1) Pattern-making, (2) casting, (3) boring, (4) turning, (5) key-waying; and the total time of these five operations must not exceed three weeks. Now it is a perfectly simple job for a clerk to enter on to a card the order number of the job, order of operations, and date that it should leave each operation; and this card may be used for an exposed record in the following way:

Photograph on Fig. 19 shows a board which was installed for dealing with a wheel and clutch delivery problem. Orders were sent to the works with a card on which was given the order of operations with the dates planned to suit the delivery promise. These cards were placed in the card-holder on the board under the date on which the casting should arrive and in the casting operation line (horizontally). As soon as the casting arrived it was taken to the work exchange which was alongside the board. The

ticket was then moved from the casting-date position to the next "operation—date" position on the board, the information as to which was the next operation and date being on the card.

The same method was adopted throughout, and work was given out by the work exchange clerk, who could see from the board the order of urgency; thus those parts which were behind time were automatically given out first to that operation group foreman who was requiring work for a machine. In this way, if deliveries were running late as against promises, the lateness was balanced—that is, divided evenly over all the articles—and instead of some coming out to time and others running several weeks late, all were completed at approximately the same number of days late. Thus the law of mutual accommodation was applied to the customer, and very beneficial results were obtained, for customers do not object to deliveries coming out a few days late, but they do object to a promise being broken two or three times on a small order, which occurs when no order of urgency of work is obtainable systematically.

The value of this method of exposed record is felt in several other ways. Thus, information

can be obtained for urging the foundry, or vision is supplied as to the operation in the works where congestion is occurring, and steps can be taken to ease this congestion by getting extra hands or working overtime. But the greatest value is obtained, not on unassembled articles as in the example taken, but on articles which should be ready for assembling on a certain date—for if each part for a clutch is given the same final date, then this automatic method of speeding up those parts which are most behind time enables the assembly to be taken in hand at the appointed time; whereas if there is no direction and control established it is certain that assembly will be held up for one or two parts.

Thus is obtained balance by a perfectly simple rule of putting that part on the machine which is most behind the time of the promised date.

There are many firms in existence to-day who make promises for delivery absolutely regardless of any possibility of keeping that promise. Some firms, having as much as six months' work ahead, unblushingly promise a fortnight's delivery because they would lose the order if a longer date was given. Now exposed records cannot be installed when the basis of

the information for that exposed record is a lie; but as soon as that firm accepts truth and the possibility of losing orders at first owing to speaking the truth, then a start can be made towards installing an exposed record which will help them in far more ways than they, with their limited vision, can see.

This method of co-ordinating direction and control of miscellaneous manufacture complies with the laws and axioms.

The order of urgency is co-ordinated with the position of material into one control; hence the law of unity of control is accepted. It has already been pointed out how the law of mutual accommodation is applied to the customer, and the student can see how this law is also applied in other ways.

As regards the axioms, direction of each part is supplied on the card which is placed on the board (Axiom A); this direction is maintained by the operator in charge of the exposed record and work exchange—in other words, the work exchange co-ordinates all the control points in the line of direction, and vision is supplied in many ways, such as by being able to see which group of operations is most behind time, consequently decision can be made regarding overtime.

It is hardly necessary to touch on the parallel between this type of miscellaneous manufacture and other types such as are so numerous. The number of factories in which this type of exposed record can be adapted is legion, and in every case with great benefit, both as regards effecting economies and improving output and deliveries.

In some factories a work exchange already exists, which means that the work of installing an exposed record system of this type is half accomplished. In most factories, though, a little more pluck would result in more standardization of work in those factories. When a firm makes up its mind that it is going to standardize a certain line of goods, then by putting one or two travellers out it may be certain that the cost of those travellers will be more than paid for by the increased output obtained by standardizing.

Tradition often stands in the way of making these changes, and tradition is often the greatest enemy of progress. Those who are familiar with "The Jungle Book" (Rudyard Kipling) will remember the tradition among the Bander-log (Monkey People): "What the Bander-log think now the jungle will think later." This tradition is found in some shape or form in

every nation, trade, city, and individual. It is a connecting-link which exists between man and monkey, and is perhaps the greatest example of a tradition which hinders progress.

In order to start the foundations of the new world of manufacture it is necessary to sort out from the traditions of the past those traditions which are based on common sense—to sort out the true traditions from the untrue traditions, the true records from the untrue records, and to build only those true traditions and records into the foundations of the new structure. For example, Sheffield has many true traditions as regards manufacture—quality is one of these true traditions; but against these true traditions must be balanced traditional methods of manufacture, which many years ago were common sense and true, but which to-day, owing to research and progress of other manufactures, are lacking in common sense and truth.

Now these lectures deal with common-sense methods for directing and controlling manufacture, and in all these methods common-sense laws and axioms are applied; and the result in every case has been "simplification," not "complication" because the problems have been reduced to their lowest common multiple. It follows that research carried on along the parallel

lines of processes in manufactures must lead to "simplification," because if it does not lead to this result the lines are not parallel.

Planning.

"Planning" is a word which, as applied to direction and control of manufacture, means "the providing of an efficient order in which the work should be executed."

Many firms engaged on standardized production have started planning or order-of-work departments, and have experienced considerable difficulty in getting the planning department recognized; and the reason for this difficulty has for the most part arisen by disregarding the law of unity of control.

In every works the main planning department should be the works manager's office, and if the works manager knows his job he issues instructions to his foremen as to the parts that he requires every day, week, or month.

The duty of the foreman in charge of the department is to plan the work in his department so that he delivers the parts that are asked for.

The works manager must not ask impossibilities—he may only ask for 75 per cent. of what he knows that department can produce,

and he instructs the foreman to fit in any other work with that 75 per cent. If the works manager asks for impossibilities the foreman eventually despises him and disregards his instructions.

Hence in order to plan it is necessary not only to know the capacity of the machines but the number of workers and structure of the organization.

Consider, as an example, works employing 1,000 workers; the works manager is the captain over these 1,000 workers, but he cannot be expected to know the capabilities of each, so he divides the 1,000 workers into ten departments and places captains over each 100, which captains he may term "foremen."

The foreman, again, cannot watch the individual work done by each worker, and appoints captains over each 10 workers; these captains may be called "charge hands."

Thus, for every 1,000 workers there may be 100 charge hands, 10 foremen, and 1 works manager, and that works manager's word must be law to the foremen, the foremen's word must be law to the charge hands, and the charge hands' word must be law to the worker.

Now if the works manager plans 75 per cent. of the work each week from his knowledge of

the capacity of each department, and if he can issue instructions to each department weekly, then the foreman can divide this plan among his 10 charge hands and supply them with additional work to fill up the extra 25 per cent.; or the works manager can supply an additional approximate order of urgency beyond the 75 per cent. to the foreman.

Thus the works manager holds the reins of total output by delegating his authority, except for orders of urgency of work, to 10 foremen. The foreman holds the reins of departmental output in precisely the same way, and the charge hand holds the reins of output from 10 workers in precisely the same way. In this way is a "homogeneous structure," and consequently the most perfect form of organized control, obtained.

If, however, the works manager does not accept the law of unity of control, if he attempts to decide which worker shall do a certain job, or which machines shall be allocated to a certain piece of work, then he is taking over the control of that department, which control he has delegated to the foreman; and immediately he attempts to do this he is guilty of breaking the law of unity of control. If, however, the foreman is doubtful as to which charge hand the

work should be given out to, then he should consult his works manager.

The same applies right through this structure: the director must not give orders to the foreman direct, he must give these to his works manager; otherwise there exists dual control, there coexist two separate points at one end of a straight line which are competing in controlling the direction of that line.

Now whether it is the Prime Minister, the director, works manager, or foreman, he will find that holding the reins of ten men provides sufficient work without interfering with subordinate's work. All interference is breaking the law of unity of control, and spells inefficiency.

In the last lecture mention was made of position-of-work forms; these forms may be filled up weekly for all the standard articles, so that the works manager can review and note those parts which are most behind time. The total of these parts when roughly analyzed should not exceed approximately 75 per cent. of the capacity of each department, and lists should be issued to each department each week giving this order of urgency, and if necessary supplying an order of urgency beyond. The foreman should then concentrate his attention primarily in making arrangement so that this

portion of his weekly output is definite. This constitutes the main portion of weekly or short-date planning, and where exposed records exist need not take up more than about an hour of the works manager's time every week.

Now the works manager must plan his work far farther ahead than a week—he should, especially when dealing with mass-production, plan not less than three months ahead, depending to some extent on whether material and supplies are difficult to obtain. In the mass-production example discussed in the last lecture it was found necessary to have a quarterly planning of machine power and requirements from departments. This planning was really part of the quarterly balancing—for balancing leads to planning. The quarterly balance was carried out against the unexecuted orders, with a small addition in each case for emergency orders. The result of this balance was reduced to orders for parts and orders for material, and the orders for parts were investigated in the works manager's office so that he should know that sufficient orders were being placed in each department to keep the machines busy until the next quarterly balancing. In passing it is as well to mention that the new balancing orders automatically cancelled the remains of

the previous balancing orders, and consequently these new orders started clean sheets in each department.

When this exposed record balancing and planning system was inaugurated at the beginning of 1917 it was found that the parts were out of balance by more than 20,000,000 parts—the total of many years of accumulating confusion from a system in which the light was extremely dim. Within a year of establishing this system these 20,000,000 parts were reduced by 16,000,000, which when considered as about 4,000 parts per working hour continuously for a year may be reckoned as a quick rate to bring order out of confusion. This result, which was obtained by providing an efficient order in which the work should be executed (planning), was only secured by co-ordinating light with direction and control.

Storekeeping.

Tremendous benefit can be obtained by keeping exposed records in the stores.

The most efficient exposed record for many stores is a ticket on the outside of each bin which states the quantity that there is inside that bin. When more is put into that bin the quantity is added, with the date; and similarly when

material is taken out the quantity is subtracted and the date given.

This exposed record stock ticket should also state the "ordering level" and the "ordering quantity" at that level.

There are several ways of guaranteeing that this ordering level is not overlooked. For many articles a visible level may be provided. Thus, if the ordering level for a certain size of rivet is one hundredweight, the stock may be kept with a piece of sacking or wire-netting separating the hundredweight at the bottom of the bin from those above, so that the storekeeper knows that when he has to issue rivets from below the wire-netting more must be ordered.

Nor is this the only advantage, for the fact that he knows when the stock is exactly a hundredweight enables him to check his exposed record, which is on the bin, and enter the corrected stock figure if there is any slight accumulated inaccuracy in his record. Now if that record is in a book in his office instead of being exposed on the side of the bin it is more than likely that he will forget to mark in the book the corrected stock.

Thus it is seen how a simple piece of wire-netting may establish a control point in the

line of direction of flow of material and prev confusion or inaccuracies in records.

There are endless methods for keeping visi levels—boxes of drills may be marked " To issued only when other stock is exhauste and these boxes may have a card fixed to th which only requires sending to the purch department as a notification that the stock down to the ordering level and that more m in consequence be ordered.

No matter what form of visible level is cided upon it is advantageous to have exposed record stock card alongside material so that any inaccuracies can be c rected immediately the actual stock is kno Truth is an exacting master. It is useless have a record which is days behind: what wanted is the exact position at that cont point, which is called " now," in the line time.

Stocktaking, as mentioned in the sec lecture, should be looked upon only as a me of checking the position, and it follows tha the stock can be arranged so as to check its then it is arranged in the most efficient mann and the captain of that ship can hand over another at twenty-four hours' notice.

LECTURE VI

DIRECTION AND CONTROL OF FINANCE BY EXPOSED RECORDS

IN the second lecture it was pointed out that the direction of flow of finance is opposite and parallel to the direction of flow of material, and that in consequence it is necessary to concentrate primarily on material direction.

Now exposed records for finance are just as important as exposed records for the position of work, and lead to still greater co-operation between master and man; but so far no exposed financial records have been installed co-ordinating the laws and axioms, and also using the same control points as have been used for the material direction exposed records. Consequently it is not possible to give an actual example, but it will be obvious that, unless the laws and axioms are applied and the same control points used, the law of unity of control will be broken and a state of dual control exist. Further, there is no reason whatever why the same control points should not be used, since it is only the

direction of flow of finance which is opposite to the direction of flow of material, for the lines are parallel.

This opposition in direction of flow accounts for the difference of view which exists between the engineer and the chartered accountant. These two professions are looking in opposite ways, and cannot in consequence see the same landscape.

But if the engineer co-ordinates the financial direction of his business with the material direction, he places himself in a position so that he can see the chartered accountant's landscape, and this leads to a great reduction in the work of the chartered accountant.

If, however, the engineer does not co-ordinate his financial direction with material direction, then the chartered accountant will eventually do so and become works manager, and the works manager will have to take a subordinate position instead of employing the chartered accountant as an assistant.

The inefficiency of the world to-day is mainly due to the enormous mass of non-productive workers—prices for articles have to include the wages of these non-productive workers.

Exposed records must in every case—providing the laws and axioms governing direction

and control are co-ordinated with them—reduce the non-productive labour, and a reduction in non-productive labour means an automatic increase in productive labour.

This lack of co-ordination in the country to-day between material direction and financial direction is dual control, and consequently very inefficient. This inefficiency manifests itself by increasing the number of non-productive workers and by time being wasted in endless ways. Can anyone justify balance sheets being published which are beyond the workmen's comprehension and only intelligible to the chartered accountant? Balance sheets, which are co-ordinated with material direction, cannot be camouflaged. Many balance sheets to-day are so camouflaged (through ignorance) that labour leaders cannot see the direction in which the financial ship is sailing. And yet the directors, who issue such balance sheets, are in many cases really anxious for the new world of industry to be built on sure and true foundations. Do directors realize that, in all probability, the non-productive workers in this country will be reduced in number by considerably more than 50 per cent. when the impossibility of dual and plural control is appreciated and unity of control established? Do

they realize that they are directors in name only and that to provide things honest "in the *sight* of all men" is their foremost duty?

In many cases, when buying an article, the user to-day pays from twice to fifty times the cost of the wages paid to produce that article. Consider the case of a sewing machine. Before the war, a machine which sold for about £5 was turned out from the factory at a price which meant perhaps 15s. in wages to all the productive workers engaged in manufacturing it and the raw material from which it was made. The balance of over £4 was absorbed in non-productive wages. This example is mild as compared with such articles as patent safety razors, some of which were sold at perhaps over forty times the cost of the productive wages paid. The critic replies to this by saying that either advertising is an exposed record, or that the cost of advertising must be considered as productive. The answer to this is that advertising is an exposed record, but does not co-ordinate the laws and axioms governing direction and control in that exposed record. How many firms would dare to advertise and co-ordinate the laws and axioms governing direction and control in that advertisement? How many firms would dare to advertise a 10s. 6d.

book and state that the cost is made up as follows:

		s.	d.
(1)	Paying off capital expended in publication	0	9
(2)	10 per cent. royalty for author	1	0·6
(3)	Printing and binding	2	0
(4)	Cost of material, paper, etc.	1	0
(5)	Publisher's overhead charges, etc. ...	1	0
(6)	Advertising	1	0
(7)	Trade discount for salesman	3	0
(8)	Working margin for profit, etc.	0	8·4
	TOTAL	10	6

Yet this is the author's estimate of the way in which each 10s. 6d. would be dissembled, and there is every reason why this record should be exposed.

The general public will agree (1) that either interest must be paid on capital or the expenditure wiped out as early as possible, (2) that the author must be paid for the many weeks' work expended in writing this book, (3) that the printers and binders must be paid for their work, (4) that the cost of material must be paid for, (5) that publishers must have overhead charges, (6) that there must be some means of bringing useful articles to the notice of the general public, (7) that distribution by the medium of shops must be paid for (a nation of shopkeepers necessarily require to be paid), and (8) that in

any enterprise there must be a margin for profit.

Why hide the truth and create a feeling of distrust in the general public that they are being asked to pay an exorbitant price? And yet the productive labour bill is probably less than 20 per cent. of the price of the book.

The most difficult thing to decide in a factory is the line of demarcation between productive and non-productive workers.

Work, as mentioned in the first lecture, is divided into the groups of manual and/or mental work.

Now while the productive worker must think what he is doing, he is primarily engaged to do some physical work in a factory, to dissemble, form, or assemble certain material (or to alter the position of that material which is part of the forming group). This is the clearest line of demarcation for classifying the productive worker. All who are not engaged for this purpose must be classified as non-productive so far as actual manufacture is concerned.

Now as soon as the manufacturer has settled upon his line of demarcation between productive and non-productive he can expose his cost into a few main groups.

The financial chart (Fig. 5) shows ex-

posure into four main groups: (1) Payments for billets, (2) payments to rolling mills, (3) wages, (4) miscellaneous payments; and the sum of these four must be less than the price obtained for the article in order that a safe working financial margin may be provided, in just the same way as extra allowances in weight of material have to be made in order to insure the final weight required. Thus the actual margin required in weight of pig iron to produce a cast which will provide 40 tons of bars can only be ascertained by weighing the cast iron and subtracting from this the weight of the bars produced; and this margin when reduced to a percentage will vary to some extent.

The parallel in financial direction for this loss in cast to the manufacturer is profit to the manufacturer, for actual profit can only be obtained by subtracting the money which is paid out for material, wages, etc., in order to produce that article, from the money received for that article. Here again, this, reduced to a percentage, will vary. Provision must of course be made for increase or decrease in stock as shown in the monthly corrective profit or loss chart.

Here, then, is a simple financial record which should be exposed by every firm in the country

to the general public. The result will be an increase in production and productive workers, and a decrease in the price of commodities and non-productive workers.

Those who start this simplest of all exposed financial records will be doing the country a very excellent service. Those who will switch over non-productive workers on to productive work will also be doing the country a very excellent service. For prices cannot drop much until the number of productive workers rises in proportion to the non-productive workers.

A certain percentage of non-productive workers must always be necessary; but all those non-productive workers should be thinkers or teachers, and not routine parrots or destructive critics.

SUMMARY.

"And the light dwelleth with Him."—DAN. ii. 22.

AN attempt has been made in these lectures to prove how true records lead the way to progress; how exposed records, in which the laws and axioms governing direction and control have been co-ordinated, are symbolical of true records; and how the inherent weight of truth in these records breaks in pieces that distrust and lack of mental cohesion which exists to-day between master and man, between Capital and Labour, between the iron and clay of industrial unrest.

There are two types of criticism concerning exposed records. One type of critic says: "I can see how it can be applied in such businesses as you have mentioned, but my business is much more complicated."

The answer to this critic is that exposed records can be applied to every business, and the laws and axioms governing direction and control can be co-ordinated with the exposed

records. The solution may not be known for every business, but by research into any business the solution can be found.

The second type of critic, especially those who have seen installations of exposed record systems in which the laws and axioms are co-ordinated, says: "The whole system is so simple that it is incredible that it should not have been discovered before."

The answer to this critic is in the affirmative, for, as far as the author knows, exposed records co-ordinating direction and control of manufacture constitute a new discovery. So far as is known the two laws of unity of control and of mutual accommodation have not been definitely connected in this way before.

Moreover, in the author's opinion, there are only two laws governing direction and control because these two laws are absolutely parallel to those two duties of man which have been preached through Christendom for the last 1,890 years; and when lines of thought are parallel it is only necessary to know the direction of one line in order to determine the direction of the other line. Thus, to expect to find more laws governing direction and control appears to be asking for failure by disregarding the value of a parallel.

At present, from a mathematical aspect, direction and control by exposed record is more in its infancy than geometry was in the time of Thales and Pythagoras, whose work Euclid digested and gave to posterity as an exposed record. Developments in those days were slow; developments in these days will be rapid, and this generation will see exposed records developing at a furious pace.

America will soon be copying the old country, for those who have studied factory organization in that country state that they have nothing which can compete in efficiency with the exposed records systems in this country which co-ordinate direction and control.

As regards other continents, there are men now in Australia who, after studying various systems in this country, know that the exposed records co-ordinating direction and control must beat any other system every time. These men are going to try their hand in installing exposed records in Australia.

In all things in which development is rapid warnings should be issued, and two warnings are now given.

Firstly, success will not attend the efforts of those who attempt to instal exposed records unless a determined effort is made to accept

and apply these laws individually and collectively to the factory and the individual.

Secondly, having arrived at a solution to the problem, this must be checked and cross-checked with the laws and axioms. If there is any point at which these do not apply, then it is necessary to start on another line of thought. Very often the least obvious road leads to the greatest panorama, and in order to obtain the greatest view of a factory and the greatest efficiency in the staff and workers in that factory, time must not be grudged in finding the road. The solution should be simple when it is found, but in many cases it is difficult to find owing to the large number of roads leading in other directions. But there is a solution to every business, and the advantages of finding this solution are so numerous that the cost of the time may be repaid a thousand times within the first year.

Against this, if a system is in operation or encouraged which does not comply with these laws and axioms, the parties guilty of encouraging that system will sooner or later find themselves installing more system to look after that system, which in three words may be stated as " the blind leading the blind."

Remember that exposed record systems, in

which the laws and axioms governing direction and control are co-ordinated, must supply truth, instantaneous information, decision, balance, vision, and lead to trust and confidence between master and man, between the thinker and the doer. Whereas hidden records or secret diplomacy are largely responsible for the chaos and lack of mental cohesion in the industrial world to-day.

In these lectures the author has attacked the masters rather than the men, because the responsibility for industrial unrest lies primarily with the masters. During the war many masters spent valuable time in squeezing the Ministry for higher prices for their manufactures. Many men are to-day copying these masters.

Masters in engineering works would do well to realize more fully the responsibility of their position, not only as directors or managers in their own works, but as heads or chief thinkers in a profession which is pivotal for all material progress.

Lethargy on the part of directors in adopting methods of co-ordinating direction and control, which are proved to be true, can only result in extending the period of convalescence of this country. Men of vision have been warning the

country for some time that a revolution would take place after the war. These men are perfectly right—a revolution is taking place to-day, not a revolution of bloodshed but a revolution of thought. One phase of this revolution of thought is that of co-ordinating trust between the thinker and the doer. A revolution of thought along these lines must carry the country farther and produce deeds, for behind every deed there is a thought.

Might of the roaring boiler,
  Force of the engine thrust,
Strength of the sweating toiler—
  Greatly in these we trust.
But back of them stands the schemer,
  The thinker who drives things through;
Back of the job the dreamer
  Who's making the dream come true.